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Annual Scientific Reports of the Indian Agricultural Research Institute

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SCIENTIFIC REPORTS

OF THE

INDIAN AGRICULTURAL RESEARCH INSTITUTE

FOR THE YEAR ENDING 30TH JUNE, 1959.

PRINTED IN INDIA BY THE MANAGER GOVERNMENT OF INDIA PRESS
NASIK ROAD AND PUBLISHED BY THE MANAGER OF PUBLICATIONS DELHI-8
1962

Agric. Res. Inst.
Pusa

SCIENTIFIC REPORTS

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FOR THE YEAR ENDING 30TH JUNE, 1924

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1925

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I. PREFACE

The Indian Agricultural Research Institute, now located at New Delhi and popularly known as the I.A.R.I. or "Pusa Institute", was originally established by the Government of India in 1905 at Pusa, a village in North Bihar. The establishment of the Institute was greatly helped by the benefaction of an American philanthropist, Mr. Henry Phipps, after whom the main laboratory building at Pusa, and later the laboratories of the Division of Soil Science and Agricultural Chemistry at New Delhi, have been named. The Institute was first named Agricultural Research Institute and it was later renamed, Imperial Institute of Agricultural Research, Imperial Agricultural Research Institute and, finally, Indian Agricultural Research Institute.

The establishment of the Institute, in fact, marked the beginning of agricultural research on organised scientific lines in India. During the early years at Pusa, pioneering work was done at this Institute by eminent scientists, like J. W. Leather in agricultural chemistry, Edwin J. Butler in mycology and plant pathology, H. Maxwell-Lefroy and T. Bainbrigge Fletcher in entomology and Albert Howard in the breeding of improved varieties of crop plants, including the famous "Pusa" wheats. In subsequent years, notable work was done in sugarcane breeding by T. S. Venkataraman at the Sugarcane Breeding Sub-station, Coimbatore (South India) which until recently formed a part of this Institute. The "Co" varieties of sugarcane bred by him are known all over the world. The most notable recent achievement of the Institute has been the production of a series of improved, disease resistant wheat varieties (now well known as the New Pusa or "N.P." wheats). In the course of the development of this Institute, the expansion of research in some crops resulted in the establishment of new institutes. The foundation of research in cotton, silk, lac, tobacco, potato and sugarcane in India was first laid by this Institute which nursed the research activities in these subjects till they were later taken over, each by a separate research organisation, such as the Bhagalpur Silk Institute, Bhagalpur (Bihar), the Indian Lac Research Institute, Ranchi (Bihar), the Central Tobacco Research Institute, Rajahmundry (Andhra Pradesh), the Central Potato Research Institute, Simla (Punjab) and the Sugarcane Breeding Institute, Coimbatore (Madras State). The organisation of research in cotton was taken over by the Indian Central Cotton Committee, Bombay in 1921.

The great earthquake of Bihar in 1934 caused considerable damage to the Institute's buildings and properties at Pusa. It was then decided to shift the Institute to its present site in New Delhi. The transfer was completed in 1936. Here the Institute stands today, a beautifully-laid-out, 1100-acre colony, about 4 miles west of the New Delhi railway station. The latitude is 28.4° N, the longitude 77.10° E, and elevation above mean sea level 750.046 ft. The maximum and the minimum temperatures during the year range between 52.6° F and 116.0° F and 30.0° F and 91.8° F respectively, and the average annual rainfall is about 23 inches, of which about 2-3 inches are received during the winter months. The soil type is light, sandy to clayey loam.

Since 1945, and especially after Independence, the Institute has expanded considerably its facilities of expert staff, buildings, equipment and experimental fields. It is today regarded as the premier institute in which there exist the best facilities that are available in the country for the conducting of basic and applied research in almost all the major disciplines of agricultural science and for imparting postgraduate training of the highest

order in these disciplines. The Institute is under the direct administrative control of the Union Ministry of Food and Agriculture and works in close cooperation with the Indian Council of Agricultural Research (commonly known as the I.C.A.R.) which is concerned with promoting, coordinating and financing research schemes on agriculture and animal husbandry in India.

The five Sections of the Institute which were in existence at the time of the transfer from Pusa, have grown into the full fledged Divisions of Agronomy, Botany, Entomology, Mycology and Plant Pathology, and Soil Science and Agricultural Chemistry. The Division of Agricultural Engineering was established in 1945. A section of Horticulture was started in the Division of Botany in 1954 and in 1957 it became a separate Division of Horticulture. Thus the Institute now has seven major Divisions, each under a Head of the Division. The over-all charge of the Institute vests, since 1945, in a full-time Director who is assisted by a part-time Joint Director and the Administrative staff of the Directorate. In 1958, the All-India Soil and Land Use Survey started functioning as a separate unit of the Institute, under the charge of the Chief Soil Survey Officer. The Institute has under its control a total of 11 substations located all over the country, excluding the 19 regional soil testing laboratories so far established and the centres and Sub-centres set up in the country under the coordinated Maize Breeding Scheme, the work under which the Institute helps to co-ordinate on behalf of the I.C.A.R.

Each of the Divisions, except at the moment the Division of Horticulture, is housed in separate buildings, each one complete with laboratories, glass houses, workshops etc. and research and auxilliary staff. The I.A.R.I. library, possessing over 1,50,000 books and about 1200 periodicals, is considered to be the biggest agricultural library in India. The Division of Agronomy has bred, and maintains, a Sahiwal herd of milch cows which is regarded as one of the most-consistent performing herds of the world. In the Division of Botany, extensive living collections of crop plants and related species have been built up with the assistance of the Plant Introduction and Exploration Organisation located in that Division. The programme of mutation research under way in that Division, would receive a great fillip when the "Gamma Garden" with its powerful 200-curie source of radioactive cobalt-60, starts functioning next year. A valuable National Pusa Insect Collection is housed in the Division of Entomology, and the mycological herbarium (*Herbarium Cryptogramae Indiae Orientalis*) and the Indian Type Culture Collection of fungi and bacteria, in the Division of Mycology and Plant Pathology. The Radio-tracer Laboratory is attached with the Division of Soil Science and Agricultural Chemistry. Also located in that Division is the Cartographic Laboratory and the coordinating centre of the all-India chain of soil testing laboratories.

Besides the regular programme of research, the various Divisions of the Institute operate a number of research projects financed either by the Ministry of Food and Agriculture itself or by bodies like the Indian Council of Agricultural Research. These include, besides several others, a project on all-India trials on fertilizers and land use and a co-ordinated maize breeding scheme dealing with research on hybrid maize. In recent years the institute has been entrusted, on an increasing scale, with the coordination of research projects on a regional basis and in several such projects it is receiving the excellent co-operation of foreign organisations like the Indo-U.S. Technical Cooperation Mission and the Rockefeller Foundation. In an effort to carry the fruits of research to the farmers, the Institute is carrying out, since 1950, extensive work in a block of villages in Delhi State under its Delhi Intensive Cultivation Scheme.

Post-graduate training constitutes an important part of the Institute's activities. Besides short-term and refresher courses, regular 2-year courses in the major disciplines of agricultural science, leading to the award of the Diploma of Associateship of the Institute, have been given at the Institute since 1923. This system of post-graduate training was reorganised in 1958, when the post-graduate School was set up and the Institute was accorded the status of an university for organising courses of instruction leading to the awards of the M.Sc. and Ph.D. degrees. The courses are now given on the lines of the course-credit system in vogue in the American Universities. The Post-graduate students' hostels provide residential accommodation to about 300 M.Sc. and Ph.D. students. The Institute has received the generous cooperation of the Rockefeller Foundation in this educational project.

The Institute is annually visited by numerous visitors—dignitaries, administrators, scientists and farmers from within the country as well as from abroad. They have all been appreciative of the unique research facilities obtaining here and also of the efforts made by the Institute in the service of Indian agriculture.

II. REPORT OF THE DIRECTOR

1. INTRODUCTORY

One of the most important events of the year related to the inauguration of the Post-graduate School at this Institute on the 6th of October, 1958 by the Hon. Shri Ajit Prasad Jain, Union Minister for Food and Agriculture. Since 1923 the Institute was organising "2 year post-graduate course in the various major disciplines of agricultural science leading to the award of the Diploma of Associateship of the Institute. The Institute has now been given the status of an University, under the University Grants Commission Act, 1956 (3 of 1956), for the purpose of awarding the M.Sc. and Ph.D. degrees. The course of instruction has been patterned on the lines of that prevalent in the American Universities. In the organization and operation of the Post-graduate School the Rockefeller Foundation have extended their generous assistance by providing a considerable amount of equipment and by making available the services, for short durations, of eminent scientists including Prof. E. C. Stakman, and Dr. P. O. Ritcher, and also of the Library expert, Dr. Dorothy Parker.

The Central College of Agriculture, which was merged with the Institute in 1951, was closed down with effect from the 1st May, 1959. The surplus staff of the College was absorbed in suitable posts in the Institute.

Further progress was made in the establishment of a "Gamma Garden" at this Institute for mutation research. The 200-curie Cobalt-60 Source has been received. The construction work in connection with the project was completed and the Atomic Energy Establishment at Bombay have fabricated the actuating mechanism for automatic raising and lowering the radiation source by means of electronic devices. The Gamma Garden is expected to go into operation during the next winter.

As in the previous years, a short training course of radio-tracer techniques was organised this year also, in the Division of Soil Sciences and Agricultural Chemistry, for the benefit of trainees deputed by the State Departments of Agriculture and Central Research Institutes. At the suggestion of the Indian Council of Agricultural Research, a 20 day refresher course in cytology, genetics and plant breeding was organised in the Division of Botany for teachers in agricultural botany in the various agricultural colleges in India.

In the project on the establishment of a chain of soil testing laboratories at different locations in India under the Institute's Soil Testing Service, 22 laboratories have now been set up.

The second in the series of research reports which is being issued by the Institute in a mimeographed form for the benefit of research workers in the country, was issued during the year under report. This report, on the "Relative efficiency of Urea" deals with the results of experiments conducted at the Institute and elsewhere in the country on the efficacy of urea as a nitrogenous fertiliser in comparison with ammonium sulphate. The next one in the series records notes on some plant materials introduced by the Plant Introduction and Exploration Organisation at this Institute during the period 1946-56; the research report has been written up and is awaiting release.

Among important changes in the staff mention may be made of the filling up of the post of Head of the Division of Botany by Dr. A. B. Joshi. Dr. S. Krishnamurthi, Head of the Division of Horticulture, relinquished his post on the 29th April, 1959 to take up his appointment as Principal, Agricultural College and Research Institute, Coimbatore.

2. SUMMARY OF MAIN RESULTS OF RESEARCH

Division of Agronomy.

Soil Fertility

In the long-term Pusa Permanent Manurial-*cum*-Rotation Experiment, there were indications of less seasonal variations in yield with the application of organic manures, as compared with chemical fertilisers. In maize, a comparison of yields from NP and NPK treatments suggested that the supply of potassium constituted a factor limiting the crop yield. The application of nitrogen at 30 and 60 lb. per acre to linseed increased the crop yields by 4.8 mds. and 7.1 mds., respectively, over the unmanured control. In an experiment on wheat, it was observed that the application of phosphate at 60 lb. per acre, together with phosphobactrin, greatly increased the quantum of available phosphorus than when phosphobactrin was not applied.

Field crops

An yield of 81.3 mds. per acre was obtained with the variety, N.P. 130, of paddy when the crop was spaced at 10 inches × 10 inches, fertilised at 90 lb. N per acre, and was earthed up to reduce lodging; planting 6 seedlings per hill appeared to give better results than 2-4 seedlings per hill. N.P. 824 came out as the best-yielding wheat variety in a major yield trial. The highest cane yield of 878 md. per acre was given by the sugarcane variety, Co. 1109. In cauliflower, the application of 5 tons of farm yard manure—120 lb. N—80 lb. P_2O_5—40 lb. K_2O per acre was found to be the optimum manurial treatment for obtaining high yields. For turnips, the optimum fertiliser requirement was 40 lb. N—40 lb. P_2O_5—20 lb. K_2O per acre. Tomato showed a linear response to nitrogen doses, but the time of nitrogen application did not appreciably reflect on yield. Planting potato tubers on ridges, combined with late earthing up, gave an yield of 288 md. per acre as compared to 231 mds. given by "flat" planting of tubers and late earthing up.

Weed Controls

Field experiments with chemical weed-killers gave gratifying results. In the Delhi villages served by the Institute's Intensive Cultivation Scheme, 130 acres were sprayed with 2, 4-D, which resulted in an average increase of about $2\frac{1}{2}$ mds. in wheat yield per acre at an additional cost of Rs. 7.50 per acre. Post-emergence spraying with M. C P. B. gave extra wheat yields of 5.3 mds. per acre, as compared to an additional yield of 4.2 mds. obtained through hand-weeding; the M. C. P. B. treatment cost Rs. 7.00 per acre, as against Rs. 16/- for hand-weeding. Complete control of *baru* (*Sorghum halepense*) was achieved by 6 cultivations followed by T.C.A. treatment at 15 lb. per acre.

Irrigation investigations

In sugarcane, 35.25 acre inches of irrigation, in addition to a rainfall of 36.8 inches, resulted in an acre yield of 1,144 mds. More frequent irrigations, at low moisture tension

(0.2 to 0.3 atmosphere) helped in obtaining maximum yields of green fodder in berseem. For furrow-irrigation of wheat, which leads to economy of irrigation water, a simple attachment for the *desi* plough, for making ridges and furrows at sowing time, was designed and encouraging results were obtained from its use.

Spray-fertilisation

Spray application of 30 lb. N—40 lb. P_2O_5 to the tomato crop resulted in an yield of 358 mds. per acre as compared to 200 mds. obtained by applying the same dose of the fertilizers to the soil. Similarly, spray application of zinc, at 1 lb. per acre together with 120 lb. P_2O gave 927 mds. of green berseem fodder, whereas the spray application of 120 lb. P_2O_5 along gave 812 mds.

All India Co-ordinated fertiliser trials

Under an I.C.A.R. Scheme, 178 factorial experiments were conducted on 30 Model Agronomic Experimental Centres in 13 States of the Indian Union. Besides these, 4774 simple field trials were conducted on cultivators' fields.

Pasture grasses and legumes

Hubam clover sown in rows along with wheat at the rate of 15 lb. per acre gave a fodder yield of 189 mds. per acre, with only two additional irrigations. The yield of wheat was not depressed.

Agricultural economics

Studies were initiated on land transformation and farm planning and budgeting in seven of the Delhi villages covered by the Institute's Intensive Cultivation Scheme. Increased size of holding was observed to be associated with a higher intensity of tillage operations while smaller holdings had a higher cropping intensity and, in consequence, lower tillage intensity. More farm yard manure was applied per acre on smaller holdings than on the larger ones.

Statistics

Studies were in progress on the heritability of milk yield in the Sahiwal herd, as worked out by the intra-size regression method. The heritability of the Cello line was determined as being 62 per cent. Crop cutting experiments conducted in 7 randomly selected villages, out of the 19 Delhi villages under the Delhi Intensive Cultivation Scheme, indicated that the application of 20 lb. N—20 lb. P per acre resulted in a yield increase of 3.0 mds. per acre in wheat. Statistical analysis of data on 388 manurial experiments on several crops conducted over 22 years since 1936-37, was completed; a bulletin, entitled "Manuring of Crops" and embodying these results, is being written up.

Division of Agricultural Engineering

A two-row groundnut planter has been fabricated, incorporating the patented seed-picking mechanism evolved by this Division. This design is a sequel to a one-row model which was subjected to extensive field trials in groundnut growing regions of the country. This machine is under field trials.

A bullock-drawn float was developed and fabricated. It was tried on the farms of the Agronomy Division and its working was satisfactory. It was found that it could level up to two hundredth of a foot.

Some Austrian types of scythe were put to further field tests at the Agricultural Research Substation, Karnal, for harvesting wheat. Two men working with a scythe could harvest about 0.5 acres in a day of 8 hours and also collect the crop; the coverage obtained with a crew of the same size, working for an equivalent period of time with sickles, came to only 0.2 acres.

Besides research on agricultural implements, the Division also carried out tests on a number of devices and implements, received by it from elsewhere; these included four types of Tractors—David Brown 2D, Landmaster, Russian DT20 and Kubota.

Division of Botany

Plant Breeding and Genetics

1. *Wheat.*—As a result of the regional trials conducted at several centres in the wheat-growing tracts of India with the newly-evolved "N. P. 800-series" of disease resistant wheat varieties, N.P. 823, and N.P. 824 came out as the most successful wheats over a wide range in the plains of northern India. In the lower hills of the Himalayas, N. P. 829 outyielded all the standard varieties; N. P. 824 has also done very well in this region and N. P. 792 is finding favour with farmers in the Paonta Valley and other tracts as a late-sown crop after paddy. Further improvement, as regards yield and rust resistance has been done in N. P. 710 and N. P. 718—two most successful N. P. wheat varieties. Two very promosing varieties, N. P. 834 and N. P. 835, which have given excellent performances in preliminary trials in Bihar, Bengal and Orissa are also ready for large-scale testing. At Wellington, strains of *Samba* wheat (*Triticum dicoccum*), which appear to be superior to N. P. 200, have been bred.

2. *Maize.*—Work on hybrid maize was in progress under the all-India Co-ordinated Maize Breeding Scheme financed by the I.C.A.R. and coordinated by this Institute. An extensive germplasm bank, comprising open-pollinated varieties, inbred lines and single- and double-crosses, has been built up and was under evaluation at all the main centres and sub-centres of the project. Tests of 308 top crosses have given excellent results, the yield increases over K. T. 41, the standard open-pollinated variety, ranging from 27 to 107 per cent.

3. *Millets.*—Several promising selections have been made in *Jowar* (*Sorghum vulgare*), in respect of high grain yield, from the cross of the indigenous variety, "Early Prodigy" with an Algerian variety—Saeve Qrome. In *bajra* (*Pennistum typhoides*), two bold-seeded types from Ghana have significantly outyielded the check variety, T. 55 of Punjab.

4. *Linseed.*—In the X2 generation of the high yielding rust susceptible variety—N.P. 12 irradiated with X-rays and critically screened for resistance to rust (*Melampsora lini*), one resistant plant, which seems to possess all the other characters of the parent type, has been isolated.

5. *Cotton.*—As a result of evaluation work carried out in the exotic collections, two types—Sealand 7 (from the U.S.A.) and K. 3814 (from the U.S.S.R.) have appeared to be useful for breeding work. The former has a halo length of 39 mm., while the latter type possesses a halo length of 29.7 mm. and a high density of lint fibres on the seed giving a ginning out-turn of 39.6 per cent.

6. *Vegetables.*—(a) *Tomato.*—Some of the F_1 hybrid combinations under preliminary tests gave yield increases ranging from 28 to 104 per cent. over the popular, high-yielding variety "Sioux".

(b) *Lady's finger* (*Bhindi*).—"Pusa Sawani", a recently bred type which, unlike all other *bhindi* varieties, remains free in the field from symptoms of the yellow-vein-mosaic varus disease, has given excellent performances at several centres in the country.

(c) *Carrot.*—By crossing European-type carrot varieties which produce roots of good quality but the seed of which can be produced only in the hills of India, with Asiatic types of inferior root quality, good-quality types have been produced; the seed of these can be produced in the plains.

7. *Pasture Grasses.*—An interesting range of intraspecific variation has been noticed, in respect of morphological, ecological and cytological features, in the important species of forage-grasses, such as *Cenchrus ciliaris, C. setigerus, Panicum antidotale, Chrysopogon montanus, Sehima nervosum* and *Iseilema laxum.*

8. *Essential oil-bearing spice plants.*—Superior types, in respect of yield and essential oil content, have been isolated in fennel (*Foeniculum vulgare*), *Sowa* (*Anethum sowa*), Coriander (*Coriandrum sativum*), *Ajwain* (*Carum copticum*) and Cumin (*Cuminum cyminum*). Some of these types have given encouraging performance in regional yield trials.

9. *Algae.*—A case of four-spored heterocysts, not reported so far in the Myxophyceae, was recorded in *Nostochopsis lobatus* collected from Assam. One new species of *Bulbochaete* and four new forms of *Oedogonium* were recorded in the material from Kerala. Interesting types were noticed, in respect of very minute details of wall structure, as a result of electron microscopic photographs taken in several diatom species.

Cytology and Cytogenetics

Monosomic analysis in bread wheat (*Triticum aestium*) indicated that the epistatic gene-BI, located on Chromosome IX was involved in the radiation induced mutation from non-beardedness to full beardedness in the variety, N. P. 809. In a trial, conducted at Delhi, with two stiff-strawed mutants from N. P. 809, the mutants responded well to high levels of fertiliser application, while the control plants tended to lodge heavily. The mutations observed in cotton and tobacco appeared to be largely polygenic. In potato, irradiation with P 32 and S 35 has given several somatic mutations. The radiation-induced flower forms in annual chrysanthemum and cosmos were found to be genetically determined. These mutant forms make the inflorescence more attractive than the control material. Dose fractionation studies on barely have suggested that X-ray induced chromosome breaks remain open for reunion several hours after breakage. In *Delphinium,* X-ray treatment of seed has been used to demonstrate inter-bivalent competition for chiasmata.

By grafting the jute species, *Corchorus olitorius* and *C. capsularis,* reciprocally, a greater percentage of fruit setting was obtained in the crosses between the two species.

Crop Physiology

Last three years' results confirmed that the application of boric acid, at 20 lb. per acre (which gives about 3 lb. of boron), appreciably increases wheat yields.

Plant Introduction

760 samples of seed and planting material were introduced from abroad. The introduced material included salinity tolerant plants, ornamental trees, grape vines and Naranjila fruit. Among the recent introductions, those which appear promising include West Indian cherry, Russian comphrey—an important fodder plant, and an African variety of *bajra* (*Pennisetum typhoides*) with ears measuring as much as 4 to 4.5 ft.

Division of Entomology

Taxonomy

The preparation of a monograph on the Indian species of the family, Ichneumonidae, on the lines of the fauna of India, has been in progress. A new subfamily, phyllogasterotinginae, including a new *Phyllogasterotingis,* and a new species *acheranthi,* were added to the five existing subfamilies of Tingoidea. Five new species, namely, *U. euphorbiae, U. indicus, U. pusaensis, U. sidae* and *U. zizyphifolius* from the Indian region were added to the existing eleven species of the genus *Urentius* Distant. Two new species namly *Anigrus dehliensis* and *Meenoplus indicus* were added to the seven species of the family Meenoplidae (*Fulgoroidea*) already recorded from the Indian Union. The genus *Meenoplus* was recorded for the first time from the Oriental region.

Insect Parasitology

The growth of *Corcyra* larvae was found to be better on a diet of crushed jowar (*Sorghum vulgare*) than on a synthetic diet. This problem was investigated with a view to study the fecundity, longevity and sex ratio of *Bracon gelechiae* and *Trichogramma minutum* reared on *Corcyra* larvae fed on different diets.

The biology of the chalcid egg parasite of *Pyrilla perpusilla* was studied in detail. Seventeen species of parasites and predators were reared from different insect pests. Out of these, five were new species and one of them appeared to belong to a new genus. The biology of the latter, belonging to the family Scelionidae, was studied in details. A catalogue of the species of the world, belonging to the subfamily. Aphidiinae (Fam. Braconidae)—a group of considerable economic importance, was prepared.

Trichogramma minutum, Bracon gelechiae, B. brevicornis, Apanteles angaleti and *Glyptomorpha deesae* were mass bred in the laboratory and a culture of *Chelonus rufus* was also begun from field collected material.

Ecology and Toxicology

Field observations on the bionomics of the painted bug confirmed previous findings that they collect in large numbers under harvested bundles of mustard plants and the population of the pest decreases with the rise in temperature.

On the basis of three years' experiments on the control schedule of mustard crop, it is now recommended that Gamma BHC, at a concentration of about 0.1% can be applied at an interval of 20 to 30 days. In maize, three treatments, *viz.,* a parathion—DDT mixture,

gamma BHC and endrin, resulted in higher yields than those obtained in untreated plots. Similarly, in cotton, yield was higher in the plots treated with endrin and parathion. Surface dusting of field bunds, containing Phadka eggs, with BHC, proved to be very effective in killing the nymphs when they emerged after the first monsoon showers. In experiments on the control of termites infesting the wheat crop (N.P.718) sown under un-irrigated conditions, the damage in plots treated with 5 per cent. aldrin, used at 40 lb. per acre, was 6.2 per cent. as against 26.4 per cent. in the untreated control; the grain yield was also higher in the treated plots.

Studies on the persistence of DDT and BHC on different vegetable crops showed that there was quite a quick decline in the amount of residue in most cases; the spray residues were comparatively more, and persisted longer, than the dust residues.

Insect Physiology

Experiments were conducted on lipid metabolism in *Lasioderma serricorne* with a view to finding out the role of intracellular microorganisms. Traces of certain types of lipids in experimental diet were found to interfere with the manifestation of symptoms of lipid deficiency. *Dysdercus* sp. nymphs could survive on artificial diet offered in the form of pellets up to 30 days and they moulted thrice. Techniques were developed by using which *Dacus cucurbitae* could be reared on rice and milk media. New rearing techniques were evolved for *Sitophilus* and *Bruchus,* pests of stored cereals and pulses respectively. *Chilo zonellus,* a serious pest of maize and jowar, was successfully reared on artificial diet.

Investigations with the help of radioactive isotopes

Assaying of the body parts of the adult of *Dysdercus koenegii* Fabr. indicated that it readily picked up 'Schradan' from film. The insecticide got distributed in all parts of the body, and in the alimentary canal it accumulated mostly in the fore and hind gut.

Division of Horticulture

Pomology

Collections of superior germplasm are being built up in this Section in respect of fruit crops, such as mango, citrus, grapes, pomegranate and papaya. *Barwani*—a papaya variety from Rajasthan has given very good performance at Delhi as regards fruit yield and quality.

Vegetables

In cucumber, the application of maleic hydrazide (200 ppm) and L-naphthaleneacetic acid (100 ppm) increased the number of female flowers significantly. Appearance of female flowers on lower nodes of main axis was noted in all the treatments and the plant regulators increased the female flower to male flower ratio. In cowpea, spraying with maleic hydrazide was effective in suppressing the apical dominace, resulting in the increased production of lateral shoots.

Hybrid vigour studies in brinjal showed that when Pusa-purple Long was used as the female parent, a high degree of heterosis was noticeable. The best combination was with Hyderpore, which gave outstandingly increased yields over the parents. The hybrid seemed to exhibit a considerable degree of frost and root-knot nematode resistance.

Fruit and Vegetable preservation

A dried product of satisfactory quality has been obtained from litchies for which a sulphitation technique has been developed. By a simple pretreatment a considerable improvement in colour and appearance has been effected in the sun drying of tomato slices.

In the preservation of raw mango slices for preparation of chutney during the "off" season, pretreatment of the slices for 24 hours in a solution containing common salt, sulphurdioxide and acetic acid was found to help against spoilage by yeast and mould: when packing the slices for storage, powdered salt has to be added.

Central Vegetable Breeding Substation, Katrain

Beans.—Three exotic varieties of French bean, namely, Wax podded (EC. 1906), EC 8146 and Giant Strigless (EC. 5843), have been found to be substantially higher yielding than the control variety Giant Stringless Green Pod.

In turnip, some promising segregates have been selected in F_3 and BC_2 material of the crosses between Asiatic and temperate varieties of turnip. These selections produce larger roots and have given higher yields of roots than the commonly-grown temperate varieties; they were also early.

Division of Mycology and Plant Pathology

Fungal Diseases

1. *The Wheat Rusts.*—During the Survey of Simla Hills, two species of grasses, one of them belonging to the genus *Bromus,* were found infected with yellow rust under natural conditions.

In the seedling resistance tests, E. 2025 and H 28 Sel. I were found to be resistant to all the individual races of brown rust. In the tests with the mixture of races of individual rusts, E. 4248 and nine hybrid selections were found to be resistant to black rust, three hybrid selections to brown rust and 23 selections and types to yellow rust. The wheat variety E. 3123, which was reported to be resistant to all the races of black rust in previous years, was found to be susceptible at high temperatures (65° to 95° F) to races 15, 15-C, 34, 40 and 122 and 194, though it remained resistant to these races at lower temperatures (43° to 70° F).

Studies on the survival of black rust races in mixture were continued and a combination of races 15 and 21 was maintained for 8 generations on five wheat varieties. The relative proportion of the two races was determined at the end of each generation and it was found that race 21 increased in proportion on N.P. 4 and N.P. 718, whereas the proportion of race 15 went up in case of the varieties Pb. C. 519, N.P. 710 and Agra local.

2. *Loose smuts.*—Of the 60 wheat varieties tested for resistance to loose smut at Delhi under field conditions, 30 remained free from smut infection. Amongst the smut-free varieties, N.P. 822, N.P. 823, N.P. 824, N.P. 825, N.P. 826, E. 997, E. 2025, E. 2140, E. 3117 E. 3319, HD(52)-34, HD(52)-60, HD(53)-103 and HD(53)-110 have consistently remained free from infection during the last three years' tests. Infection obtained in the susceptible varieties, used as control, was as high as 90-97%.

3. *Bunt.*—In the varietal resistance tests against the Hill Bunt at Simla, 21 out of the 100 wheat varieties tested reacted as resistant to *Tilletia foetida.* Eleven varieties, which had proved resistant to *T. foetida* in the last year's tests, proved resistant to *T. caries* also. Analysis of 26 samples of *T. foetida* and 11 of *T. caries* indicated the presence of 8 races of the former and 7 of the latter. Of these, only two races of *T. foetida* and one of *T. caries* were commonly encountered.

4. *Barley Rusts.*—In seedling resistance tests, four varieties of barley were found to be resistant to a mixture of races of yellow rust. However, none of the varieties, tested against the individual races of black rust, or their mixture, was found to be resistant.

5. *Sugarcane diseases.*—Studies on the comparative virulence of 30 different isolates of the red rot fungus, *Colletotrichum falcatum* (4 dark and 26 light-type), on the ten standard cane varieties showed that some of the recent isolates were more virulent than the earlier ones. In the varietal resistance tests, 186 cane varieties were tested by the Plug method and 97 by the Nodal Infection method. Cane varieties Co. 1149 and Co. 1159 were found to be resistant in the former test and Co. 1080 in the latter.

Of the 163 varieties tested against smut, 17 gave less than 5 per cent. smut infection. Six of these varieties have reacted as resistant in previous tests also and may therefore be considered as resistant to smut.

6. *Rust and Wilt of linseed.*—Of the 599 linseed varieties tested in the adult stage, 486 proved to be resistant. Sixteen linseed varieties were tested for resistance to wilt in a wilt-stick plot; of these, only two-N.P. (RR)9 and B 5128, showed a fair degree of resistance.

7. *Wilt of pigeon pea.*—Of the 20 pigeon pea varieties tested for resistance, two varieties-N.P.(W.R.) 15 and S. 37 in pots, and three varieties-N.P.(W.R.) 15, S. 37, and S. 79 in the field, did not develop any wilt symptoms.

8. *Rust of safflower.*—The heterothallic nature of this rust was established.

Bacterial and Nematode Diseases

A bacterial stalk and ear rot of maize, showing either rotting of the basal portion of the stalk or of ear and ear-shank, was found to be widely prevalent and appeared to be extremely destructive to certain strains of maize in the principal maize growing areas of the country. The pathogen has been identified as *Erwina carotovora F.* sp. *zeae.* Also, the presence of phages in the waters of the river Ganges, collected at Hardwar and Allahabad, was demonstrated, using *Escherichia coli* as a test organism.

A number of vegetable crops (including tomato, brinjal and *bhindi*) in the Institute Farm were found to be severely infested with root-knot nematode. 'Molya' affected wheat and barley plants, collected from Rajasthan, yielded a large number of cysts of *Heteroderâ* sp. as also species of *Fusarium* and *Helminthosporium* from the roots. Analysis of soil samples from the diseased fields also showed the presence of a heavy population of nematodes—*Heterodera* sp.

Virus Diseases

The bottlegourd mosaic virus was purified; electron micrographs of the purified virus preparation showed that the virus particles are rod-shaped. *Kagzi* lime was found to be a useful differential host plant for the 'Tristeze' virus, causing the Quick-decline in

citrus. In addition to *Toxoptera citricidus, Myzus persicae* and *Aphis gossypii* were established to be vectors of the Quick-decline virus. "Grassy-shoot' of sugarcane was transmitted to *Pennisetum ciliaris* through the vector, *Longiunguis sacchari,* while maize proved to be a symptomless carrier.

A virus causing yellow-net symptoms in tobacco was transmitted by grafting, and through the white-fly (*Bemisia tabaci*), to several species of *Nicotiana, Beta vulgaris* and aster. Cowpea mosaic virus was found to be seed-transmitted and *Aphis craccivora, A. gossypii, A. cronymi* and *Myzus persicae* were established to be its vectors. *Macrosiphoniella sanbornii* and *Aphis gossypii* were established to be additional vectors for broad been mosaic and *Aphis rumicis* for Chinese *sarson* mosaic. *Cassia tora* was shown to be a new and useful local lesion differential host for the tobacco mosaic virus.

Physiology of Fungi

Work on the physiology of light and dark type isolates of *Colletotrichum falcatum* showed that the dark type isolate No. 78 required biotin for its growth, but addition of this vitamin did not increase its virulence. However, an advance dose of nitrogenous compounds, both organic and inorganic (except nitrites), significantly increased its linear spread of infection in the cane varieties Co. 312 and Co. 647.

Bacterisation of pigeon pea seed with *B. subtilis* showed that considerable amount of the antibiotic was produced on the seed-coat which helped in the reduction of wilt incidence.

Effect of Atomic Radiations on Microorganisms

Further studies on the biochemical mutant of *Colletotrichum falcatum,* obtained through irradiation with P showed a linear correlation between growth of the fungus and concentration of P-aminobenzoic acid (0.001 to 0.01 micrograms per ml.), indicating thereby that the mutant can be used for microbiological assay of the vitamin. Furthermore, the mutant was found to have lost its pathogenicity which could be restored to some extent by incorporating a small quantity of the vitamin in the inoculum.

Fungicides

Tolymercury chloride and mercury acetate were screened for their fungicidal properties, with *Alternaria tenuis* as test organism, and were found to be effective at 1 ppm.

A comparative field trial with nine fungicides for the control of black rust of wheat showed that four sprayings with Parzate liquid [disodium ethylenebis (dithiocarbamate)] plus zinc sulphate, at an interval of 15 days from the first week of February onwards, reduced the intensity of black rust infection from 40 to 65 per cent. in the control to 0 to 2 per cent. in the sprayed plots.

Systematic Mycology

Erysiphe sikkimense sp. nov. was reported on *Castanopsis tribuloides* and *C. indica.* In addition, ten new host records for powdery mildews were established. Taxonomic studies on miscellaneous Indian fungi were also continued as a result of which 5 new species and 17 new host or fungus records for India have been established.

Division of Soil Science and Agricultural Chemistry

Agricultural Chemistry

Synthetic slow-acting nitrogenous fertilizers, which simulate the action of natural organic manures, have been developed by (i) chemical complexing of urea with formaldehyde and (ii) absorption of urea solution in saw dust, leaf powder and dry dung. The materials retain excellent physical condition and liberate nitrogen gradually to feed the growing crop according to its requirements. Loss by leaching is also reduced.

Further improvement in the efficiency of illumination of gas lamps has been achieved by either mixing 25 per cent air with the gas from the cowdung gas plant or by passing through a trap containing petrol.

Physical Chemistry

The addition of bentonite to soil receiving FYM treatment in laboratory experiments has been found to increase the degree of aggregation of clay plus silt in soils from Bichpuri, Pusa, Kuttanad, Agarthala, Chalakudi and Aryadu and to decrease it in the soil from Delhi. The same treatment also increased the ratio of Group I/II clay-humus complex in the soils from Pusa, Bichpuri, Powarkhera, Coimbatore (red or black), Kuttanad, Aryadu and Agarthala. The availability of phosphate also increased in the soils from Bichpuri, Coimbatore (red or black) Aryadu and Kuttanad but it lowered in that of Powarkhera. Bentonite may therefore be used with advantage on the soils from Bichpuri, Kuttanad and Aryadu and only under special circumstances on other soils.

The potassium ion activity in the plant and potassium absorption ratio of the equilibrium solutions were found to be the greatest for tobacco and least for wheat, *mung* occupying an intermediary position. This appears to account for the relative need of these crops for potasic fertilizers.

Organic Chemistry

Following the pilot plant investigations for the production of terpene ethers and alcohols, nearly 3 tons of synthetic pine oil has been produced. Extensive tests of the product in different commercial establishments have shown that the product compares favourably with natural pine oil.

Physics

Electron micrograph of a plant virus, *cucumis-2c,* prepared in the Mycology Division of this Institute, indicated that this virus consists of a rod shaped particle of about 20 mμ thickness.

Biochemistry

In pot experiments it has been observed that the percentage of absorption of nitrogen and phosphorus by the maize plants is significantly more when the nutrients are sprayed on the leaves than when the same is applied to the soil.

Mitochondria prepared from berseem have been found to dephosphorylate adenosintriphosphoric acid. The first labile-P is liberated in a very short period while the second labile-P is released after long period of incubation, suggesting thereby the presence of both ATP-ase and ADP-ase in the mitochondria.

Available copper, zinc and molybdenum were estimated in some of the major Indian soils by the use of the *Aspergillus niger* method. The amount of available micro-untrients has been found to be low in most of the soils studied, a major portion of the elements present in the soil being in unavailable form.

Microbiology

Studies on the bacterisation of soil with phosphobacterin (Russian culture), Fosfo 24 (Czechoslovakian culture) and an organism isolated in India from the glands of *Cassia occidentalis* showed varying increase in the yield of berseem grown in the field at Delhi. The Russian culture was most active in releasing phosphorus from superphosphate, rock-phosphate and bone-meal.

Preliminary pot experiments with an active strain of Azotobacter, isolated from Mussoorie soil, suggested that the organism could help in appreciably increasing the yield of wheat; the experiments are being followed up.

Soil Testing Service

Twentytwo soil testing laboratories have started functioning in the different parts of India. Two more are expected to start soon. About 56,000 soil samples were analysed and fertilizer recommendations were made on the basis of these analyses.

Radio Tracer Investigation

Phosphate response curves for wheat and paddy have been studied on a large number of soils. In general the plateau of the response curves was observed to start at 80 lbs. P_2O_5 acre dose. Highly significant exponential inverse relationship has been found between logarithm of 'A' value and % yield response in both wheat and paddy.

Binding energy of soils for phosphate has been studied for 70 different soils. In alkaline soils the value did not vary much, but in acid soils the range was wide. While pH and organic carbon were negatively related with binding energy, sesquioxides showed a positive relationship. It was found that organic matter in these acid soils influences the force with which phosphorus is attached to the sesquioxides. It has also been found that bulky organic matter significantly increases the movement of phosphorus in soils.

Comparative efficiency of phosphatic fertilizers for rice has been studied on a number of soils. In acid soils, ammonium phosphate, followed by metaphosphate, was far superior to superphosphate or other carriers.

In both wheat and paddy, it was found that application of organic matter to a number of soils significantly increased the uptake of total phosphorus but decreased the uptake of fertilizer phosphorus.

ALL INDIA SOIL AND LAND USE SURVEY.

Survey work was carried out in four of the principal soil zones of the country, and with special reference to the catchment and sub-catchment areas of the various river valley projects, including the Bhakra Nangal, Chambal and Mahanadi projects. The area covered by reconnassance, as well as detailed survey, totals over 4½ lakh acres. In the cartographic laboratory, standard procedures have been laid down for colour separation, mapping and symbolisation of soil survey data and over 1300 maps have been reproduced.

3. THE POST-GRADUATE SCHOOL

The year under report constitutes a landmark in the history of post-graduate education in agricultural science which is one of the major functions of the Institute. This year, the Institute was granted the status of an university, under the provisions of the University Grants Commission Act of 1956, for the purposes of organising and conducting courses of post-graduate instruction in the diverse branches of agricultural science, leading to the award of the M.Sc. and Ph.D. degrees.

Established on the recommendation of the Indo-U.S. Team on Agricultural Education, the Post-graduate School at the Institute was inaugurated, with a colourful ceremony on the 6th October, 1958, by the Hon'ble Shri Ajit Prasad Jain, Union Minister for Food and Agriculture. On the same occasion, the Hon'ble Minister laid the foundation stone for building an additional wing to the I.A.R.I. Library.

In the fostering of this project, the Institute has received generous support from the Rockefeller Foundation. The Foundation has offered for the School a considerable amount of equipment and books; besides, it has deputed a number of eminent scientists, for specific periods of time, to act as visiting professors and advisers. Dr. P. O. Ritcher of the Oregon State College joined the Division of Entomology on the 1st September, 1958. Dr. E. C. Stakman, Emeritus Professor at the University of Minnesota, worked in the Division of Mycology and Plant Pathology from the 12th January, to the 8th May, 1959.

Dr. (Miss) Dorothy Parker, a library expert, who arrived on January 5, 1959 rendered valuable service in the task of reorganising the I.A.R.I. Library with a view to adapt it more fully to the growing needs of the post-graduate School.

To assist the Director and the Heads of Divisions in shouldering effectively the increasing responsibilities of research and post-graduate instruction, a number of gazetted and non-gazetted posts were sanctioned by the Ministry of Food and Agriculture under the Post-graduate School. The gazetted posts include the Dean, six Professors, a number of Assistant Professors, and a Registrar. The functioning of the Post-graduate School, in the academic sphere, is regulated by the Post-graduate Council; the Dean acts as its Chairman, the Director as member *ex-officio,* and the Registrar as the Secretary. The gazetted staff of the Institute participating in post-graduate instruction are constituted into the Post-graduate Faculty; members on the Faculty are nominated by the Institute Council on the recommendation of the Post-graduate Council and the Dean of the Post-graduate School acts as the Chairman of the Post-graduate Faculty. In the organisation of instruction in agricultural statistics, the Statistical Wing of the Indian Council of Agricultural Research—now designated as the Institute of Agricultural Research Statistics, has given its full co-operation, and officers of that Institute also are represented on the Post-graduate Council and the Post-graduate Faculty.

The courses of instruction are now modelled largely on the pattern obtaining in the American universities and the objective is to give the students a full mastery of, and to help him to achieve a position of leadership, not only in his major field of study but also in minor supporting disciplines. The syllabi have been drawn up into a number of discreet courses, each course being assigned a definite number of credit hours for the theory and practicals covered by it. About 99 such courses were incorporated in the calendar of the School issued in October, 1958. Each M.Sc. and Ph.D. student is advised, by his panel of advisers, to take the desired number and combination of courses. An M.Sc. student is required to take a minimum of 45 credits of course work; for the Ph.D. course, the credit

requirement is governed by the background and need of the individual student with no specified minimum. The minimum residential requirement for the M.Sc. degree, as well as the Ph.D. degree, is two years from the date of admission to the course.

The popularity of, and the country's need for, Post-graduate training of the quality imparted by the Institute is reflected in the fact that in 1958 as many as 256 applications for the Ph.D. course and 563 applications for the M.Sc. course were received for the 50 Ph.D. and 100 M.Sc. seats available. The number of students admitted to these courses is given in Chapter V.

The Associate Diploma Courses

86 students, who successfully completed their post-graduate training and four departmental candidates were awarded the Diploma of Associateship of this Institute in their respective subjects. The names of these candidates are given in Chapter V. With the inception of the Post-graduate School in the Institute in 1958, these have been discontinued, The last batch of the Diploma course students, admitted in 1957, will be passing out in September, 1959.

Short Course

As in the previous years, three-months course on the use of Radio-isotope in agriculture was held this year also. Besides this, six Vigyan Mandir Officers were given a six-week training in the Divisions of Mycology and Chemistry and four trainees were given six-months training in Maize Breeding in the Botany Division.

4. GENERAL

(a) Gazetted Staff

Directorate

Director	Dr. B. P. Pal, M.Sc., Ph. D. (Cantab.), F.L.S., F.N.I., F.B.S., Hony. Member, Genet. Soc., Japan.
Joint Director	Dr. R. S. Vasudeva, Ph. D. (Lond.), D. Sc. (Lond.), D. I. C., F. N. I.
Registrar—1	Shri B. M. Pal, B.A.
Registrar—2	Shri S. L. Vachher, B.A. Hons., M.A., from 3-1-1959.
Librarian	Shri N. N. Chatterji, B.Sc., Dip. Lib. Sci., (Proficiency certificate in French, German and Russian).
Accounts Officer	Shri K. C. Gupta, B.A.

Division of Agronomy

Head of the Division	Dr. P. C. Raheja, M.Sc. (Ag.), Ph. D. (Punjab), D. Sc. (Punjab).
Professor of Agronomy	Dr. O. P. Gautam, M.Sc. (Ag.), Ph. D. (Calif.), from 1-12-1958.
Agronomist	Shri S. Sen, M.Sc.
Agronomist	Shri A. R. Khan, M.Sc. (Ag.), M.S. (Wisc.), up to 30-6-1959.
Agronomist	Dr. J. N. Sharma, M.Sc. (Ag.), Ph. D. (Minn.), up to 15-6-1959.
Asstt. Professor of Agronomy	Dr. H. S. Mann, M.Sc., Ph. D. (Kansas), from 16-10-1958.

Asstt. Professor of Agronomy .	Shri S. S. Bains, B.Sc. (Ag.), Assoc. I.A.R.I., from 6-10-1958.
Asstt. Professor of Agronomy .	Dr. N. G. Dastane, B.Sc. (Ag.) Hons., M.Sc. Ag., Ph D. (Queensland), from 6-10-1958.
Asstt. Agronomist . . .	Shri J. J. Chandnanni, M.Sc. (Ag.).
Asstt. Agronomist . . .	Dr. H. S. Mann, M. Sc., Ph. D. (Kansas), up to 15-10-1958.
Farm Superintendent . . .	Shri S. S. Bains, B.Sc. (Ag.), Assoc. I.A.R.I., up to 5-10-1958.
Cattle Officer	Shri. Gian Singh, L. V. P. Hons., P. G. Mukt.

STATISTICS SECTION

Head of the Section . . .	Dr. P. N. Saxena, M.A., Ph D. (Agra).
Asstt. Professor of Statistics . .	Shri G. Sadasivan, M.Sc. (Statistics), from 21-1-1959.
Asstt. Statistician . . .	Shri A. G. Kavitkar, B.Sc., Assoc. I.A.R.I., P. G. Training in Agr. & Animal Husb. ICAR.

AGRICULTURAL ECONOMICS SECTION

Head of the Section . . .	Dr. T. P. S. Chowdhury, B.Sc. Ag., M.Sc., Ph. D. (Wisc).

AGRICULTURAL SUBSTATION KARNAL

Asstt. Agronomist . . .	Shri R. S. Gupta, B.Sc. Ag., Assoc. I.A.R.I.

PROJECT FOR IRRIGATION INVESTIGATION

Agronomist	Dr. Mukhtar Singh, M.Sc. Ag., Ph. D. (Edin.).
Asstt. Agronomist . . .	Shri R. T. Gandhi, B.Sc. Ag., Assoc. I.A.R.I.

PROJECT FOR THE SETTING UP OF POST-GRADUATE COURSE IN AGRICULTURAL EXTENSION

Professor of Agricultural Extension .	Shri S. L. Vishnoi, M.Sc. (Ag.), M.S. (Cornel), from 18-10-1958.
Agricultural Development Officer .	Shri Dewan Singh, M.Sc. (Ag.), from 1-5-1959.

SCHEME FOR INVESTIGATION ON WEED CONTROL

Agronomist	Dr. R. D. Verma, B.Sc. (Ag.), B.Sc. Hons. (Edin.), M.S. (Iowa), Ph. D. (Edin.).
Asstt. Agronomist	Vacant.

PROJECT FOR PLANT TISSUE AND SPRAY FERTILIZER INVESTIGATIONS

Agronomist	Dr. K. S. Yawalkar, B.Sc. (Ag.), Assoc. I. A. R. I., Ph. D. (Minn.)

Division of Agricultural Engineering

Head of the Division . . .	Shri R. V. Ramiah, B.E. (Mech.), M.Sc. (Iowa), M. A. S. A.E., On other duty.
.	Shri E. G. K. Rao, B.Sc. (Engg.), A. M. I. E., M. M. E. A., from 18-12-1957.
Agricultural Engineer . .	Shri J. S. Manku, B.Sc. (Engg.), A. M. I. E., from 24-10-1958.
Asstt. Engineer . . .	Shri J. S. Manku, B.Sc. (Engg.), A. M. I. E., up to 23-10-1958.
Asstt. Engineer . . .	Shri R. P. Singh, B.Sc. (Agri. Engg.), M. Sc. (Ag.).
Asstt. Engineer . . .	Shri A. S. Kahlon, B.Sc. (Ag.), B. Sc. (Civil Engg.).

SCHEME FOR SURVEY OF INDIGENOUS AGRICULTURAL IMPLEMENTS

Mechanical Engineer	Shri J. R. Badola, B.Sc. (Agri. Engg.).

Division of Botany

Head of the Division	Dr. S. M. Sikka, M.Sc. Ag., Assoc. I.A.R.I., Ph. D. (Lond.), on other duty.
	Dr. A. B. Joshi, M.Sc., Assoc. I.A.R.I., Ph. D. (Cantab.), F.B.S., from 19-1-1959.
Professor of Botany	Dr. A. B. Joshi, M.Sc., Assoc. I.A.R.I., Ph. D. (Cantab.), F.B.S., from 1-10-1958 to 18-1-59.
Plant Physiologist	Dr. R. D. Asana, M.Sc., Ph. D. (Lond.), D. I. C. (Lond.).
Geneticist	Dr. A. B. Joshi, M.Sc., Assoc. I.A.R.I., Ph. D. (Cantab.), F.B.S., up to 30-9-1958.
Geneticist	Vacant.
Cytogeneticist	Dr. M. S. Swaminathan, B.Sc., B.Sc. (Ag.), Assoc. I.A.R.I., Ph. D. (Cantab.).
Systematic Botanist	Dr. D. Chatterjee, M.Sc., Ph. D. (Lond.), on other duty.
Asstt. Professor of Botany	Dr. Vishnu Swarup, M.Sc., Assoc. I. A. R. I., Ph. D. (Kansas), from 22-12-1958 to 19-5-1959.
Asstt. Professor of Botany	Shri M. V. Rao, M.Sc., from 22-12-1958.
Asstt. Professor of Botany	Shri V. S. Mani, M.Sc., from 22-12-1958.
Asstt. Professor of Botany	Dr. S. V. S. Shastry, B.Sc. Ag., Ph. D. (Wisc.), from 23-12-1958.
Asstt. Plant Physiologist	Shri T. J. Malkani, M.Sc., M. S. (Calif.).
Asstt. Cytogeneticist	Dr. A T. Nataranjan, M.Sc., Assoc. I.A.R.I., Ph. D. (Delhi), since 15-12-1958 on deputation for higher training in the U.S.A. under Rockefeller Foundation fellowship.
Asstt. Geneticist	Shri Amir Singh, M.Sc. (Ag.), since 15-1-1959 on deputation for higher training in the U. S. A. under Rockefeller Foundation Fellowship.
Asstt. Geneticist	Shri M. Ahluwalia, B.Sc. Hons., Assoc. I.A.R.I.
Asstt. Geneticist	Shri R. K. Mehta, B.Sc. (Ag.), Assoc. I.A.R.I.
Asstt. Agrostologist	Shri P. M. Dabadghao, M.Sc., on other duty. Shri B. D. Patil, B.Sc. (Ag.) Hons., officiating.

BOTANICAL SUB-STATION, PUSA (BIHAR)

Superintendent	Shri M. D. Nandkeolyar, M.Sc.

CO-ORDINATED WHEAT RUST CONTROL SCHEME (BOTANICAL PORTION)

DELHI CENTRE

Wheat Breeder	Dr. G. S. Murty, M.Sc., Assoc. I.A.R.I., Ph. D. (Minn.), up to 20-12-1958.
Asstt. Wheat Breeder	Shri M. V. Rao,, M. Sc., up to 21-12-1958.
Asstt. Statistician	Shri Daljit Singh, B.Sc., Assoc. I.A.R.I.

SIMLA CENTRE

Asstt. Wheat Breeder . . Dr. S. P. Kohli, M.Sc. Ag., Ph. D. (Cornell), on other duty.
Dr. S. Kedharnath M. A., M. Sc., Ph. D. (Wisc.), up to 6-8-1958.

WELLINGTION CENTRE

Asstt. Wheat Breeder . . Dr. V. K. Srinivasan, M.Sc., Ph. D. (Poona).

INDORE CENTRE

Asstt. Wheat Breeder . . Shri V. S. Mathur, M.Sc. (Ag.).

PUSA CENTRE

Asstt. Wheat Breeder . . Dr. Y. M. Upadhyaya, B.Sc., Assoc. I.A.R.I., Ph. D. (Sydney).

PLANT INTRODUCTION AND EXPLORATION ORGANISATION

DELHI CENTRE

Plant Introduction Officer . . Shri H. B. Singh, M.Sc., Assoc. I.A.R.I.

Asstt. Botanist . . . Shri S. P. Mittal, M.Sc., Assoc. I.A.R.I.

CENTRAL VEGETABLE SEED TESTING STATION (BOTANICAL PORTION)

Seed Testing Officer . . . . Vacant.

SCHEME FOR USE OF RADIOACTIVE ISOTOPES IN CYTOGENTICAL STUDIES

Asstt. Cytogeneticist . . . Dr. H. K. Jain, B.Sc. Hons., Assoc. I.A.R.I., Ph.D. (Wales), up to 13-2-1959.

Asstt. Plant Physiologist . . Shri R. N. Mukherjee, M.Sc., from 1-12-1959.

SCHEME FOR ESTABLISHMENT OF UNIT FOR EMBRYO-CULTURE

Asstt. Cytogeneticist . . . Shri S. Ramanujam, B.Sc. Hons., Assoc. I.A.R.I.

SCHEME FOR CYTOLOGICAL STUDIES IN OILSEEDS

Asst. Cytogeneticist . . . Shri S. S. Rajan, M.Sc., up to 6-8-1958.

SCHEME FOR IMPROVEMENT OF ESSENTIAL OIL YIELDING PLANTS

DELHI CENTRE

Asstt. Botanist . . . Shri B. S. Joshi, B.Sc. (Ag.), Assoc. I.A.R.I.

Chemist . . . . . Vacant.

PUSA CENTRE

Asstt. Botanist . . . Shri M. G. Joshi, B.Sc. (Ag.), Assoc. I.A.R.I.

KATRAIN CENTRE

Asstt. Botanist . . . Shri P. M. Bhagchandani, B.Sc. (Ag.), Assoc. I.A.R.I. up to 7-9-1958.

JAMNAGAR CENTRE

Asstt. Botanist . . . Shri L. M. Jeswani, B.Sc. (Ag.), Assoc. I.A.R.I.

ADDITIONAL STAFF FOR THE PLANT BREEDING AND GENETICS SECTION

Geneticist	Dr. S. P. Kohli, M.Sc. (Ag.), Ph. D. (Cornell).
Geneticist	Vacant.
Geneticist	Vacant.
Asttt. Geneticist	Shri M. W. Hardas, M. Sc., Assoc. I.A.R.I.
Asstt. Geneticist	Dr. Vishnu Swarup, M.Sc., Assoc. I.A.R.I., Ph. D. (Kansas), up to 21-12-1958.
Asstt. Geneticist	Shri B. S. Fozar, M. Sc., from 1-5-1959
Asstt. Geneticist	Vacant.

SCHEME FOR THE STUDY OF GENETICS OF VARIABILITY IN ALGAE

Asstt. Botanist	Shri G. S. Venkataraman, M.Sc.

SCHEME FOR THE STUDY OF MILLING, BAKING AND CHAPATEE-MAKING QUALITIES IN WHEAT

Asstt. Plant Physiologist	Dr. A. Austin, M.Sc. (Ag.), M.Sc. (Lond.), D.Sc. (Holland.).

SCHEME FOR CYTOGENETICAL AND PHYSIOLOGICAL STUDIES IN RELATION TO FLORICULTURE

Asstt. Cytogeneticist	Dr. P. Sarkar, B.Sc. Hons., M.Sc., Ph. D. (Calif.), from 1-7-1958 to 13-2-1959.

CO-ORDINATED MAIZE BREEDING SCHEME

Senior Maize Breeder	Dr. N. L. Dhawan, M.Sc., Assoc. I.A.R.I., Ph. D. (Minn.).
Junior Maize Breeder	Vacant.
Junior Maize Breeder	Vacant.

CO-ORDINATED SCHEME FOR PRE-SOAKING SEEDS IN NUTRIENT SALTS

Asstt. Plant Physiologist	Shri S. P. Singh, B.Sc. Ag., Assoc. I.A.R.I.

CO-ORDINATED SCHEMES FOR CITRUS DIE-BACK DISEASE

Asstt. Plant Physiologist	Shri V. S. Mani, M.Sc., up to 21-12-1958.

SCHEME FOR THE STUDY OF THE ROLE OF TRACE ELEMENTS ON METABOLISM OF COTTON PLANT

Asstt. Biochemist	Dr. M. S. Naik, M.Sc., Ph. D. (Poona), from 29-5-1959.

REGIONAL STATION OF THE PROJECT FOR INTENSIFICATION OF REGIONAL RESEARCH ON COTTON, OILSEEDS AND MILLETS

Senior Cytogeneticist	Shri S. S. Rajan, M.Sc., from 7-8-1958.
Cytogeneticist	Vacant.
Plant Physiologist	Vacant.
Linseed Breeder	Dr. S. Kedharnath, M.A., M.Sc., Ph. D. (Wisc.), from 7-8-1958.

WING FOR FUNDAMENTAL PLANT GENETICAL RESEARCH

Geneticist . . . . Dr. M. L. Magoon, M.Sc., Ph. D. (Wisc.), from 23-6-1959.

Cytologist . . . . Dr. H. K. Jain, B.Sc. Hons., Assoc., I.A.R.I., Ph. D. (Wales), from 14-2-1959.

Geneticist . . . . Vacant.

Geneticist . . . . Vacant.

Division of Entomology

Head of the Division . . Dr. E. S. Narayanan, M.A., Ph. D. (Lond.), D.I.C.(Lond.), F.R.E.S., F.E.S.I.

Professor of Entomology . . Dr. S. Pradhan, M.Sc., Ph. D. (Lond.), D.Sc. (Lucknow), F.R.E.S., F.E.S.I., from 1-10-1958.

Systematic Entomologist . . Dr. M. G. Ramdas Menon, M.Sc., Ph. D. (Bom.), F. R. E. S., F. E. S. I.

Parasitologist . . . Vacant.

Toxicologist . . . Dr. S. Pradhan, M.Sc., Ph. D. (Lond.), D.Sc. (Lucknow), F.R.E.S., F.E.S.I., up to 30-9-1958.

Asstt. Professor of Entomology . Dr. B. R. Subba Rao, B.Sc., Assoc. I. A. R. I., Ph. D. (Mysore), from 30-1-1959.

Asstt. Systematic Entomologist . Dr. S. M. Chatterjee, M.Sc., Assoc. I.A.R.I., Ph. D. (Agra), F.R.E.S., F.E.S.I.

Asstt. Ecologist . . . Dr. T. V. Venkataraman, M.Sc., Assoc. I.A.R.I., Ph. D. (Madras), F.R.E.S., F.A.S.

SCHEME FOR RESEARCH ON INSECT PHYSIOLOGY

Insect Physiologist . . . Dr. N. C. Pant, M.Sc. (Ag.), Ph. D. (Lond.), D.I.C. (Lond.).

TERMITE SCHEME

Asstt. Entomologist . . Dr. H. J. Bhambani, B.Sc., Assoc. I.A.R.I., Ph. D. (Lond.).

SCHEME FOR BIOLOGICAL TESTING AND CERTIFICATION OF INSECTICIDES

Asstt. Entomologist . . Shri M. G. Jotwani, B.Sc., Assoc. I.A.R.I.

SCHEME FOR ESTABLISHING A UNIT FOR STORAGE PEST ECOLOGY

Asstt. Entomologist . . Shri P. B. Mukjerjee, B.Sc., Assoc. I.A.R.I.

SCHEME FOR SURVEY OF BENEFICIAL PARASITES OF PESTS OF AGRICULTURAL CROPS

Asstt. Entomologist . . Dr. B. R. Subba Rao, B.Sc., Assoc. I.A.R.I., Ph. D. (Mysore), up to 29-1-1959.

SCHEME FOR ENTOMOLOGICAL INVESTIGATION WITH THE HELP OF RADIOACTIVE ISOTOPES

Entomologist . . . Dr. Rattan Lal, M.Sc., Assoc. I.A.R.I., Ph. D. (Punjab).

CENTRAL VEGETABLE SEED TESTING STATION (ENTOMOLOGICAL PORTION)

Entomologist . . . Shri H. N. Batra, B.Sc. (Ag.), Assoc. I.A.R.I.

LOCUST TOXICOLOGY SCHEME

Asstt. Toxicologist . . Dr. P. D. Srivastava, M.Sc., D. Phil. (Alld.).

SCHEME FOR RESEARCH ON INDIAN HONEY BEE AT THE BOTANICAL SUB-STATION PUSA (BIHAR)

Asstt. Entomologist . . Shri P. L. Sharma, M.Sc. (Ag.).

SCHEME FOR EXPLORATION OF TOXICITY HAZARDS

Asstt. Entomologist . . Shri Y. P. Beri, M.Sc.

Asstt. Chemist . . . Shri R. S. Dewan, M.Sc. (Tech.).

Division of Horticulture

Head of the Division . . Dr. S. Krishnamurthi, B.Sc. (Ag.), M.S. (Calif.), Ph. D. (Mich.), up to 29-4-1959.

Professor of Horticulture . . Dr. G. S. Randhawa, M.Sc., M.S.A. (Toronto), Ph. D. (Mich.) & (Toronto), from 1-10-1958.

Horticulturist . . . Dr. G. S. Randhawa, M. Sc., M.S.A. (Toronto), Ph. D. (Mich.) & (Toronto), up to 30-9-1958.

Vegetable Breeder . . . Dr. B. Chowdhury, Ph. D. (Melbourne), F.R.H.S.

Fruit Preservation Officer . N. L. Jain, M.Sc. (Tech.), from 11-8-1958.

Asstt. Professor of Horticulture . Dr. Jagpal Singh, M.Sc., Ph. D. (Mich.), from 8-5-1959.

Asstt. Professor of Horticulture . Shri Ranjit Singh, B.Sc. Ag., Assoc. I.A.R.I., M.S. (Calif.), from 31-1-1959.

Asstt. Horticulturist . . Dr. Jagpal Singh, M.Sc., Ph. D. (Mich.), up to 7-5-1959.

Asstt. Vegetable Breeder . . Shri P. M. Bhagchandani, B.Sc. Ag., Assoc. I.A.R.I., from 8-9-1958.

Asstt. Fruit Preservation Officer. Shri J. C. Anand, M.Sc. (Tech.), from 8-10-1958.

Garden Superintendent . . Shri Romesh Chandra, B.Sc. (Ag.).

SCHEME FOR THE IMPROVEMENT OF WATER MELON AND MUSK MELON

Asstt. Botanist . . . Shri N. Nath, M.Sc., Assoc. I.A.R.I., from 1-5-1959.

CENTRAL VEGETABLE BREEDING SUB-STATION KATRAIN (KULU VALLEY)

Vegetable Specialist . . Dr. Vishnu Swarup, M.Sc., Assoc. I.A.R.I., Ph. D. (Kansas), from 20-5-1959.

Division of Mycology and Plant Pathology

Head of the Division . . Dr. R. S. Vasudeva, B.Sc., Ph. D. (Lond.), D.Sc. (Lond.), D.I.C. (Lond.), F.N.I.

Professor of Plant Pathology . Dr. C. V. Subramaniam, M.A., Ph. D. (Madras), D.Sc. (Madras), F.A. Sci., from 28-10-1958.

Systematic Mycologist . .	Dr. B. L. Chona, B.Sc., Ph. D. (Lond.), up to 17-10-1958.
Asstt. Professor of Plant Pathology	Dr. D. N. Srivastava, B.Sc. (Ag.), Assoc. I.A.R.I., M.S. (Wisc.), Ph. D. (Wisc.), from 22-12-1958.
Asstt. Professor of Plant Pathology	Shri R. L. Munjal, M.Sc., from 22-12-1958.
Asstt. Professor of Plant Pathology	Shri T. K. Nariani, M.Sc., Assoc. I.A.R.I., from 22-12-1958.
Asstt. Plant Pathologist . .	Dr. M. L. Gattani, M.Sc., Ph. D. (Minn.), on leave.
	Dr. Kishan Singh, M.Sc., Ph. D. (Loisiane), up to 10-10-1958.
Asstt. Virus Pathologist . .	Shri H. S. Sahambi, M.Sc.
Asstt. Plant Bacteriologist .	Vacant.
Herbarium Keeper . . .	Shri J. N. Kapoor, M.Sc., Assoc. I.A.R.I.

SCHEME FOR STUDY OF FACTORS RESPONSIBLE FOR CHANCE RED ROT FUNGUS FLORA AND ALLIED ASPECTS

Mycologist	Dr. B. L. Chona, B.Sc., Ph. D. (Lond.), from 18-10-1958.

CO-ORDINATED WHEAT RUST CONTROL SCHEME (MYCOLOGICAL PORTION)

DELHI CENTRE

Mycologist	Dr. R. Prasada, M.Sc., D.Sc. (Agra.).

SIMLA CENTRE

Asstt. Mycologist . . .	Shri V. C. Lele, M.Sc. (Ag.).
Asstt. Mycologist . . .	Dr. S. Singh, M.Sc. (Ag.), Ph. D. (Minn.).
Asstt. Mycologist . . .	Dr. M. M. Payak, M.Sc. (Ag.), Ph. D. (Poona).

WELLINGTON CENTRE

Asstt. Mycologist . . .	Shri L. M. Joshi, M.Sc.

CO-ORDINATED PLANT VIRUS RESEARCH SCHEME

SIMLA CENTRE

Asstt. Virus Pathologist . .	Shri R. N. Azad, B.Sc. (Ag.), Assoc. I.A.R.I., up to 6-7-1958.
	Shri M. L. Seth, M.Sc., from 23-5-1959.

POONA CENTRE

Virus Entomologist . .	Shri P. M. Verma, M.Sc. Hons.
Virus Pathologist . . .	Dr. S.P. Capoor, M.Sc., Ph. D. (Lond.).

KALIMPONG CENTRE

Virus Pathologist . . .	Dr. S. P. Raychaudhuri, M.Sc., Assoc. I.A.R.I., D. Phil. (Cal.), F.L.S.
Virus Entomologist . .	Shri S. N. Chatterjee, M.Sc., Assoc. I.A.R.I.

CO-ORDINATED SCHEME FOR PLANT VIRUS DISEASES

DELHI CENTRE

Asstt. Virus Pathologist . . Shri T. K. Nariani, B.Sc., Assoc. I.A.R.I., up to 21-12-1958.

SIMLA CENTRE

Asstt. Virus Pathologist . . Dr. B. B. Nagaich, M.Sc., Ph. D. (Illinois).

SCHEME FOR THE USE OF ATOMIC ENERGY IN PLANT PATHOLOGICAL RESEARCH

Asstt. Plant Pathologist . . Shri B. S. Bajaj, M.Sc.

SCHEME FOR THE STUDY OF BACTERIAL PLANT PATHOGENS

Plant Bacteriologist . . Dr. M. K. Hingorani, M.Sc., Assoc. I.A.R.I., Ph. D. (Minn.).

CENTRAL VEGETABLE SEED TESTING STATION (MYCOLOGICAL PORTION)

Plant Pathologist . . . Dr. D. Suryanarayana, M.Sc., D.Sc. (Agra).

PLANT INTRODUCTION AND EXPLORATION ORGANISATION (MYCOLOGICAL) PORTION)

Asstt. Plant Pathologist . . Dr. Gopal Swarup, M.Sc., Assoc. I.A.R.I., M.S. (Kansas), Ph. D. (Kansas), from 26-8-1958.

SCHEME FOR THE APPRAISAL OF LOSSES DUE TO PLANT DISEASE

Mycologist . . . Shri R. L. Munjal, M.Sc., upto 21-12-1958.

LINSEED RUST SCHEME

Asstt. Mycologist . . . Shri D. P. Misra, M.Sc., Assoc. I.A.R.I., from 26-8-1958.

SCHEME FOR RESEARCH ON FUNGICIDES

Asstt. Plant Pathologist . . Dr. J. S. Grewal, M.Sc. (Ag.), D. Phil. (Alld.), from 10-2-1958.

ALL INDIA CO-ORDINATED SCHEME FOR RESEARCH ON THE INVESTIGATION AND CONTROL OF RUST DISEASES OF SUGARCANE

Mycologist . . . Vacant.

Division of Soil Science and Agricultural Chemistry

Head of the Division . . Dr. S. P. Raychaudhuri, M.Sc., Ph. D. (Lond.), D.Sc. (Cal.) & (Lond.), F.R.I.C., F.N.I., on other duty.
Dr. R V. Tamhane, B. Ag., Ph. D. (Lond.).

Professor of Agricultural Chemistry. Dr. K. C. Gulati, B.Sc. Hons. (Tech.), M.Sc. Hons., Ph. D. (Punjab), from 1-10-1958.

Biochemist . . . Dr. N. B. Das, M.Sc., Ph. D. (Szeged).

Organic Chemist . . . Dr. K. C. Gulati, B.Sc. Hons. (Tech.), M.Sc. Hons., Ph. D. (Punjab), up to 30-9-1958.

Physical Chemist . . . Dr. B. Ramamoorthy, M.Sc., Assoc. I.A.R.I., D. Phil. (Allahabad)

Soil Microbiologist . . Dr. W. V. B. Sundara Rao, B.Sc. Hons., Assoc. I.A.R.I., Ph. D. (Andhra).

Soil Scientist . . .	Dr. T. D. Biswas, M.Sc., D. Phil. (Cal.).
Experimental Physicist . .	Dr. C. Dakshinamurti, M.Sc., Ph. D. (Lond.), D.Sc. (Banaras), F. Inst. P. (Lond.), on other duty.
	Dr. Y. V. Kathavate, M.Sc., Ph. D. (Bom.).
Assistant Professor of Physical Chemistry.	Dr. S. C. Das, M.Sc., D. Phil. (Cal.), Ph. D. (Leeds.), from 1-4-1959.
Assistant Agricultural Chemist .	Dr. V. Iswaran, M.Sc., Ph. D. (Delhi), from 1-5-1959.
Assistant Soil Microbiologist .	Dr. A. Sen, M.Sc., Assoc. I.A.R.I., Ph. D. (Bom.).
Assistant Soil Physicist . .	Dr. B. T. Mulwani, B. Ag., M.Sc., Ph. D. (Lond.), D.I.C. (Lond.).
Assistant Soil Survey Officer .	Shri R. S. Murthy, M.Sc. (Ag.), up to 26-10-1958.
Assistant Soil Survey Officer .	Shri S. P. Jain, B.Sc., Assoc. I.A.R.I., from 17-9-1959.
Assistant Organic Chemist .	Dr. A. R. S. Kartha, M.Sc., Ph. D. (Madras).
Assistant Soil Chemist . .	Shri A. B. Ghosh, M.Sc.
Assistant Physical Chemist .	Dr. S. C. Das, M.Sc., D.Phil.(Cal.), Ph. D.(Leeds.),up to 31-3-1959.
Assistant Biochemist . .	Dr. B. M. Lal, M.Sc., Ph. D. (Banaras).

SCHEME FOR DETERMINATION OF SOIL FERTILITY AND FERTILISER USE

Soil Scientist . . .	Dr. N. P. Dutta, D.Sc. (Cal.), A.R.I.C.
Assistant Soil Chemist . .	Dr. B. V. Subbaiah, M.Sc., Ph. D. (Bom.).

SCHEME FOR WORKING ELECTRON MICROSCOPE

Assistant Physicist . .	Shri S. C. Mehta, M.Sc., from 25-4-1959.

SCHEME FOR EXAMINING THE BEHAVIOUR OF CERTAIN ADDITIONAL CHEMICAL FERTILISERS UNDER STORAGE CONDITIONS

Fertiliser Technologist . .	Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I.

UNIT OF PHYSICS

Senior Physicist . . .	Dr. C. Dakshinamurti, M. Sc., Ph. D. (Lond.), D.Sc. (Banaras), F. Inst. P. (Lond.).

SCHEME FOR EXPANDED SOIL TESTING SERVICE

DELHI CENTRE

Special Officer . . .	Dr. R. V. Tamhane, B. Ag., Ph. D. (Lond.), on other duty.
Assistant Soil Chemist . .	Shri P. K. Oomen, M.Sc. (Tech.), up to 22-10-1958.

NAGPUR CENTRE

Assistant Soil Chemist . .	Shri V. K. Misra, B.Sc., A.I.I.S.T., Assoc. I.A.R.I.
	Shri P. M. Joshi, B.Sc., Assoc. I.A.R.I., from 1-4-1959.

CALCUTTA CENTRE

Assistant Soil Chemist . .	Shri B. B. Rudra, M. Sc., Assoc. I.A.R.I.

POONA CENTRE

Assistant Soil Chemist . .	Dr. V. K. Leley, M.Sc., Ph. D. (Bombay), from 9-7-1958.

COIMBATORE CENTRE

Assistant Soil Chemist . . Shri T. R. Srinivasan, B.Sc., Assoc. I.A.R.I., up to 22-5-1959.

LUDHIANA CENTRE

Assistant Soil Chemist . . Shri Bhagvan Das, M.Sc.

SABOUR CENTRE

Assistant Soil Chemist . . Dr. N. R. Dutta Biswas, M.Sc., Ph. D. (Cal.), up to 4-8-1958.

SAMBALPUR CENTRE

Assistant Soil Chemist . . Shri V. C. Padhi, B.Sc. Hons., Assoc. I.A.R.I.

HYDERABAD CENTRE

Assistant Soil Chemist . . Shri P. M. Joshi, B. Sc., Assoc. I.A.R.I., upto 31-3-1959.

BANGALORE CENTRE

Assistant Soil Chemist . . Shri H. G. Gopala Rao, M.Sc.

NABHA CENTRE

Assistant Soil Chemist . . Shri K. L. Nayar, M.Sc. (Ag.).

TRIVANDRUM CENTRE

Assistant Soil Chemist . . Shri H. Sankara Subramoney, M.Sc.

RAJAHMUNDRY CENTRE

Assistant Soil Chemist . . Shri P. V. Anantharaman, B.Sc. (Ag.), Assoc. I.A.R.I., from 18-3-1959.

GWALIOR CENTRE

Assistant Soil Chemist . . Shri Y. P. Bali, B.Sc. Hons., Assoc. I.A.R.I., up to 21-8-1959.

SIMLA CENTRE

Assistant Soil Chemist . . Shri P. C. Thakur, B.Sc., Assoc. I.A.R.I.

JUNAGADH CENTRE

Assistanr Soil Chemist . . Shri M. S. Khera, B.Sc. Ag., Assoc. I.A.R.I., from 16-2-1959.

BALEHONUR CENTRE

Assistant Soil Chemist . . Shri P. K. Matthews, M.Sc.

BAPATLA CENTRE

Assistant Soil Chemist . . Shri G. R. Rao, M.Sc.

JODHPUR CENTRE

Assistant Soil Chemist . . Shri S. P. Seth, M.Sc. Hons.

JABALPUR CENTRE

Assistant Soil Chemist . . Shri V. K. Misra, B.Sc., A.I.I.S.T., Assoc. I.A.R.I., from 16-4-1959.

HAZARIBAGH CENTRE

Assistant Soil Chemist . .	Shri R. K. Asthana, M.Sc.

AGARTALA CENTRE

Assistant Soil Chemist . .	Shri A. N. Sen, M.Sc. Hons.

SCHEME FOR COLLATION AND COLLECTION OF SOIL SURVEY DATA IN INDIA

DELHI CENTRE

Assistant Soil Survey Officer .	Shri S. P. Gupta, B.Sc. Hons., Assoc. I.A.R.I.
Assistant Soil Survey Officer .	Shri P. K. Thomas, B.Sc., Assoc. I.A.R.I.

KANPUR CENTRE

Assistant Soil Survey Officer .	Dr. N. R. Dutta Biswas, M.Sc., Ph. D. (Cal.), from 5-8-1958.

ALL INDIA SOIL AND LAND USE SURVEY

DELHI CENTRE

Chief Soil Survey Officer . .	Dr. S. P. Raychaudhuri, M.Sc., Ph. D. (Lond.), D.Sc. (Cal.) & (Lond.), F.R.I.C., F.N.I.
Soil Correlator . . .	Dr. K. V. S. Satyanarayana, M.Sc. (Ag.), Assoc. I.A.R.I., Ph. D. (Madras).
Cartographer . .	Shri L. M. Mathur, M.A., B.T., A.S.T.
Soil Chemist . . .	Shri R. K. Chibber, B.Sc., Assoc. I.A.R.I., from 27-9-1958.
Assistant Soil Conservation Officer	Shri R. S. Murthy, M.Sc. (Ag.), from 27-10-1958.
Stores Officer	Shri C. S. Jain, B. Com., LL. B., up to 16-9-1958.

NAGPUR CENTRE

Soil Correlator . . .	Dr. B. B. Roy, M.Sc., Ph. D. (Durban).
Assistant Soil Conservation Officer	Shri Y. P. Bali, B. Sc. Hons., Assoc. I.A.R.I., from 22-9-1958.
Soil Chemist	Shri N. K. Barde, M.Sc. (Ag.), from 22-9-1958.

BANGALORE CENTRE

Soil Correlator . . .	Dr. S. V. Govindarajan, B.Sc. Hons., Ph. D. (Lond.), D. I. C., A.R.I.C.

CALCUTTA CENTRE

Soil Correlator . . .	Shri S. Digar, M.Sc., Dip. Agri. (Cantab).
Assistant Soil Conservation Officer	Shri T. R. Srinivasan, B.Sc., Assoc. I.A.R.I., from 28-5-1959.
Soil Chemist . . .	Shri J. C. Bhattacharjee, M.Sc., from 23-9-1958

Central College of Agriculture (Up to 30-4-1959)

Principal	Dr. E. S. Narayanan, M.A., Ph. D. (Lond.), D.I.C. (Lond.), F.R.E.S., F.E.S.I.
Lecturer in Agriculture . . .	Shri Diwan Singh, M.Sc. (Ag.).

Lecturer in Chemistry . .	Dr. W. V. B. Sundara Rao, B.Sc. Hons., Assoc. I.A.R.I., Ph. D. (Andhra), on other duty.
	Dr. V. Iswaran, M.Sc., Ph. D. (Delhi).
Lecturer in Entomology . .	Vacant.
Lecturer in Physics . .	Vacant.
Lecturer in Agricultural Engineering	Vacant.
Lecturer in Veterinary Sciences .	Vacant.
Lecturer in Horticulture . .	Dr. G. S. Randhawa, M.Sc., M.S.A. (Toronto), Ph. D. (Mich.) & (Totonto), on other duty.
	Shri N. Nath, M.Sc., Assoc. I.A.R.I.
Lecturer in Mycology . .	Dr. D. Suryanarayana, M.Sc., Ph. D. (Agra), on other duty.
	Shri S. D. Gera, M.Sc.
Lecturer in English . .	Shri S. L. Vachher, B.A. Hons., M.A., up to 2-1-1959.
Lecturer in Economics . .	Shri A. S. Kahlon, M.A.
Lecturer in Botany . . .	Shri B. S. Fozdar, M.Sc.

I. A. R. I. Dispensary

Civil Assistant Surgeon . . .	Dr. R. K. Jerath, M.B., B.S.

(b) Meetings, Conferences and Deputations

As in the previous years, the Director, the Heads of Divisions, and senior members of the staff attended meetings sponsored by the different Ministries of the Government of India, the Indian Council of Agricultural Research, and the different Commodity Committees, etc. Dr. A. T. Natarajan, Assistant Cytogeneticist, and Shri Amir Singh, Assistant Geneticist—both in the Division of Botany, proceeded to the U.S.A. for advanced training, on the 5th December, 1958 and 16th January, 1959 respectively, under Rockefeller Foundation Fellowships. Serva Shri N. M. Nimgade and Shyama Charan Srivastava, both Research Assistants in the Division of Soil Science and Agricultural Chemistry, continued to be on deputation in the U.S.A. for higher studies.

In recent years, the Institute has been a venue of international conferences organised by learned societies. In January 1959, the Indian Society of Horticulture organised an international symposium on the breeding and cytogenetical aspects of fruit tree improvement.

(c) Visitors

The institute is visited by a large number of foreign dignitaries and members of scientific, industrial and cultural delegations visiting India. The important among the visitors during the year under report include His Royal Highness the Duke of Edinburgh; His Excellency the Prime Minister of Norway; His Excellency the Prime Minister of Ghana; Prof. Toan, Vice-Minister for Education, Democratic Republic of Viet-nam; Mr. D. C. Granada, Minister for Labour, Co-operative Development and Social Services, Trinidad and Tobago; Mr. Hamed Suleiman of the United Arab Republic; Shri B. Ramakrishna Rao, Governor of Kerala and Smt. B. Ramakrishna Rao; Dr. B. V. Keskar, Minister for

Information and Broadcasting, Government of India; Shri Shriman Narayan, General Secretary, All India Congress Committee; Dr. C. D. Deshmukh, Chairman, University Grants Commission; and Dr. H. Fergussen of the Indian Tea Association.

Among the foreign delegations and other visitors, mention may be made of the German Agricultural Delegation and the Russian Farmers Delegation; Mr. K. Nishimura, F.A.O. Expert; Dr. N. W. R. Steacie, President, National Research Council of Canada; Prof. Ralph Hay; Mr. R. Dangesfield; Dr. B. H. Burtt of the Edinburgh Botanic Garden; Dean Leasure, Dean Wilson and Dr. Pickett of Kansas State College; Dr. E. O. Heady of Iowa State College; Dr. P. G. Hughes from Utah; Utha Hto of the University of Mandalay; Dr. M. G. Weiss, Plant Industry Station, Maryland, U.S.A.; Dr. Louis Feinstein of the United States Department of Agriculture; and Dr. A. Zizka of the Economic Institute of Czechoslovak Academy of Science.

(d) Library

The total number of the publications received in the I.A.R.I. Library, both by way of exchange and purchase, was 3593. Eighty-eight new periodicals were added to the library during the year. 7908 books were issued out on loan, of which 995 were sent out to various scientific workers within the country. 17848 readers made use of the reading room and consulted 89,378 publications. In addition, references on topics concerning publications on specific subjects were supplied to correspondents by the Librarian and his staff.

The deputation of Dr. (Miss) Dorothy Parker by the Rockefeller Foundation Constituted an invaluable help in the reorganisation of the working of the library. A new set of reading rooms and other library accommodation is proposed to be constructed, which will complete the fourth wing of the library; the foundation stone was laid by the Hon'ble Shri Ajit Prasad Jain, Union Minister for Food and Agriculture, on the occasion of the inauguration of the Post-Graduate School of the Institute on the 6th October, 1958.

(e) Collections and Herbaria

The foreign plant introductions and indigenous collections made by the Plant Introduction and Exploration Organisation, located in the Division of Botany, numbered 1298 and 1441 items, respectively, bringing the total Collection to 22,239.

At the request of different correspondents, 657 identified insect specimens were donated to them from the National Pusa Insect Collection. The catalogueing of genera and species of the sub-family, Opatrinae, of the family Tenebriondae, as also the check lists of the families, Chrysomelidae, Nymphalidae, Saturnidae, Cochlididae, Apoidea, Vespidae, Specoidae, Coreidae and Pentatomidae, were completed.

During the period under report, the total number of cultures in the Indian Type Culture Collection, located in the Division of Mycology and Plant Pathology, was 1106. In addition, 59 cultures of different rusts and 54 virus cultures were being maintained. About 126 cultures were supplied to scientific workers and research institutions within the country and abroad. A revised list of the cultures available in the Collection was prepared. In all, 595 specimens, both Indian and foreign, were added to the Mycological Herbarium, bringing the total number of accessions to 26,540. One hundred and ten specimens, including some type specimens, were supplied to various Indian and foreign scientific workers.

(f) Research Schemes.

Work on the following research schemes, financed by the Ministry of Agriculture, Government of India (including the Second Five Year Plan Schemes, the Indian Council of Agricultural Research and the different commodity committees, was in progress in the different Divisions of the Institute during the years under report :—

Title of the Scheme	Sponsored by
Division of Agronomy—	
Improvement of pasture grasses and legumes	Indian Council of Agricultural Research.
Key Village Scheme	Government of India, Ministry of Food and Agriculture.
Project for addition to the existing laboratory of Agronomy Division	Do.
Project for irrigation investigation	Do.
Project for investigation of Weed Control.	Do.
Project for setting up Post-Graduate Course in Agricultural Extenstion	Do.
Project for Plant Tissue Tests and Spray fertilization Investigation	Do.
Project for shifting of Agricultural Research Sub-Station, Karnal.	Do.
Division of Botany—	
Establishment of Plant Introduction and Exploration Organisation	Do.
Co-ordinated Wheat Rust Control Scheme	Do.
Scheme for the Control of Bunt Disease in Wheat	Do.
Scheme for studies on the Milling, Baking and Chapati-making qualities of Indian wheats.	Do.
Scheme for the use of Radio-active isotopes in Cytogenetic Studies	Do.
Establishment of a Unit for Embryo Culture work	Do.
Scheme for setting up of a Central Seed Testing Station for Vegetable Crops	Do.
Scheme for setting up of a Cobalt-60 Field Radiation Unit	Do.
Co-ordinated Maize Breeding Scheme	Indian Council of Agricultural Research.
Co-ordinated Scheme for Improvement of Chillies	Do.
Coordinated Scheme for Research on Micronutrients with special reference to Citrus-die-back	Do.
Scheme for Improvement of Essential Oil Yielding Plants	Do.
Scheme for the study of Genetics and variability of Algae from the view point of their use in agriculture.	Do.

Title of the Scheme	Sponsored by
Coordinated Scheme for Pre-soaking seeds in Nutrient Salts	Indian Council of Agriculture Research.
Scheme for Cytogenetical and Physiological studies in relation to Floriculture.	Do.
Project for Intensification of Regional Research on Cotton, Oilseeds and Millets.	Do.
Scheme for Physiological Investigation on Autotetraploids of some Oilseed crops.	Indian Central Oilseed Committe.
Scheme for Cytological studies on some Oilseed Crops	Do.
Study of the role of trace elements in the metabolis of Cotton plant	Indian Central Cotton Committee.
Division of Entomology—	
Termite Research Scheme	Indian Council of Agricultural Research.
Scheme for Exploration of Toxicity Hazards in the use of Modern Insecticides against Cattle and Human Beings.	Do.
Scheme on the Biology and Nutrition of Insect Pests of agricultural importance.	Do.
Scheme for research on Insect Physiology	Government of India Ministry of Food and Agriculture.
Scheme for Entomological investigations with the help of Radioactive Isotopes.	Do.
Scheme on Indian Honey Bee at the Botanical Sub-station, Pusa (Bihar)	Do.
Scheme for study of Beneficial Parasites of Pests of Agricultural Crops	Do.
Scheme for establishing a Unit for Storage Pest Ecology	Do.
Scheme for Unit for Biological Testing and Certification of Insecticides	Do.
Scheme for setting up of a Seed Testing Station	Do.
Scheme for Locust Toxicology	Do.
Division of Horticulture—	
Establishment of the Division of Horticulture at the Indian Agricultural Research Institute.	Do.
Central Vegetables Breeding Sub-station, Katrain	Do.
Coordinated scheme for the Improvement of Musk-melon and Watermelon, Delhi Centre.	Indian Council of Agricultural Research.

Title of the Scheme	Sponsored by
Division of Mycology and Plant Pathology—	
Coordinated Wheat Rust Control Scheme (Mycological Portion)	Government of India, Ministry of Food and Agriculture.
Coordinated Plant Virus Disease Scheme	Do.
Scheme for use of Atomic Energy in Plant Pathological Research	Do.
Scheme for study of Bacterial Plant Pathogens	Do.
Appraisal of Losses due to Plant Diseases	Do.
Scheme for testing of Fungicides	Do.
Bunt Control Scheme (Mycological Portion)	Do.
Scheme for setting up of a Seed Testing Station (Mycological Portion)	Do.
Plant Introduction and Exploration Organisation (Mycological Portion)	Do.
Scheme for Research on Diseases of Sugarcane	Indian Council of Agricultural Research & Indian Central Sugarcane Committee.
Coordinated Scheme for Research on Fungicides	Indian Council of Agricultural Research.
Scheme for the sutdy of Factors responsible for change of Red Rot Fungus Flora and allied aspects.	Indian Central Sugarcane Committee.
Coordinated Scheme for Research on Investigation and Control of Rust Diseases of Sugarcane.	Do.
Scheme for Research on Virus Diseases of Oilseed Crops	Indian Central Oilseed Committee.
Linseed Rust Scheme	Do.
Coordinated Scheme for Improvement of Chillies (Mycological Portion)	Indian Council of Agricultural Research.
Coordinated Plant Virus Research Scheme for Eastern Zone	Do.
Division of Soil Science and Agricultural Chemistry—	
Radio Tracer and Related Investigations	Government of India, Ministry of Food and Agiculture.
Unit of Physics	Do.
Electron Microscope Scheme	Do.
Scheme for Addition to Gas House	Do.
Additional Staff for Gas House	Do.
Scheme for Foliar Application of Nutrients to Crops	Indian Council of Agricultural Research.

Title of the Scheme	Sponsored by
Scheme for examining the Behaviour of certain Additional Chemical Fertilizers under Storage Conditions.	Indian Council of Agricultural Research.
Scheme for Improvement of Essential Oil Yielding Plants (Chemical Portion).	Do.
Scheme for Exploration of Toxicity Hazards in the use of Modern Insecticides against Cattle and Human Being (Chemical Aspect).	Do.
Investigation on Phosphorus Fertilization of Cotton Plant by Radio Tracer Technique (Chemical Aspect).	Indian Central Oilseed Committee.
Scheme for training in Analytical Work for determination of Quality of Oil in small samples of Oilseeds.	Do.
All India Soil Survey Scheme—	
All India Soil and Land Use Survey Scheme	Government of India, Ministry of Food and Agriculture.
Collection and Collation of Soil Survey Data	Do.
Division of Agricultural Engineering—	
Scheme for the Establishment of a Museum of Agricultural Implements	Do.
Scheme for the Establishment of a Research *cum* Testing Centre for Bullock Driven Agricultural Implements.	Indian Council of Agricultural Research.
Scheme for the Survey of Indigenous Agricultural Implements in common use in the country.	Do.
Scheme for the Survey of Additional Indigenous Agricultural Implements.	Do.
Scheme for the Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements.	Do.

(g) Intensive Cultivation Scheme

As in the previous years, the Institute carried out extension work in a block of 19 villages in Delhi State. Besides, several members of the Institute's staff offered active assistance, as Teams of Helpers, organised under the *Rabi* and the *Kharif* Campaigns organised in the Delhi State by the Directorate of Extension in the Ministry of Food and Agriculture.

During the year, 289 demonstrations in the *kharif* season and 245 in the *rabi,* were conducted to demonstrate the value of improved varieties of crops and vegetables, of green manuring, and of improved cultural practices, such as fertiliser application in the recommended doses, line sowing, drilling of seed, etc. Through the agency of cooperative stores, 981 md. ammonium sulphate and 37 md. superphosphate were distributed. The use of Chemical weed-killers was demonstrated on 130 acres, which resulted in an extra yield of, on an average, 2½ md. per acre. Berseem was successfully introduced on seven holdings and linseed, as an alternative cash oilseed crop, was introduced on eleven holdings. About 12,000 mds. of pure seed of the wheat variety, N.P. 718, was produced by the cultivators, of which 10,854 mds., were purchased for seed by the Departments of Agriculture in West

Bengal, Delhi, Rajasthan and Orissa. In addition, about 600 mds. of seed of N.P. 824, one of the very successful N.P. wheat varieties recently released by the Institute, was produced by farmers.

Under the Key Village Scheme, natural services were provided for 133 cows and 398 buffaloes. Besides, artificial insemination was carried out on 4 cows and 50 buffaloes and 151 male calves were castrated. The staff under the Scheme treated 546 head of cattle for various diseases, vaccinated about 1200 animals with H. S. vaccine and 5041 with Rinder pest vaccine.

The pest control operations carried out during the year in the Delhi villages included field treatment against the *Gundhi* bug of paddy, the Red Pumpkin beetle, the mustard sawfly and the hairy caterpillar. Control operations against field rates were conducted on about 104 acres.

(h) Supply of Pedigree Seeds

As in the previous years, the demand for seeds of improved N.P. varieties of crops and vegetables, and especially that for seed of the N.P. wheat varieties, was quite heavy. Since the area available for seed multiplication purposes was limited, the supply of seed fell short of demand. The following quantities of pedigree seed of "N.P." varieties of different crops were supplied by the Institute.

Crop	Quantity of seed distributed	
	Mds.	Srs.
Wheat	3200	..
Paddy	257	30
Maize	313	34
Barley	16	34
Oats	56	3
Gram	165	2
Arhar	33	28
Mung	6	30
Urid	2	14
Lentil	2	30
Linseed	2	20
Sesamum	1	11
Brassica	0	30
Berseem	3	4
Cowpea (Fodder Type)	8	35
Vegetables (including peas and cowpea)	92	3
Hibiscus	0	1
Sannhemp	0	14

(i) Advisory

Besides the advisory committees of the Ministry of Food and Agriculture and of the Indian Council of Agricultural Research, including the Commodity Committees, under the same Ministry, the Director served on numerous other expert committees constituted from time to time by the various scientific organisations in India.

In addition to the normal activity of research and post-graduate training, numerous enquiries are received seeking advice on various problems, such as cultivation practices and application of fertilisers and manure, supply of pedigree seed and advice on the cultivation of these and other crops, analysis of soil and water for irrigation, identification of plant specimens and of specimens of diseased plants, cultivation of vegetable, etc. Of the numerous requests for advice which were attended to, only a few are given below.

Agronomy.—Literature on the cultivation of field and vegetable crops, on grasses and on extention methods ; control of crop weeds, including the chemical control of obnoxious weeds, such as *baru, pohli, motha,* and *bathua,* methods of conversion of farm waste into manure; water requirements of paddy and sugarcane crops; information on crops which could be sown in December; flood areas and their problems; cultivation of Russian comphrey, vegetables, *jowar, arhar,* and other crops and onion seed production; use of calcium ammonium nitrate as supplementing agent for lime in acid soils; placement of phosphatic fertilisers; phosphate fertilisation of berseem ; potash fertilisation for prevention of lodging in paddy ; prevention of lodging in sugarcane ; stilbestrol treatment for stimulation of artificial lactation in milch cattle.

Agricultural Engineering.—Selection, use and operation of agricultural machinery and appliances, especially small tractors ; problems regarding mechanisation of agriculture ; supply of working drawings to facilitate manufacture of particular implements and machines.

Botany.—Identification of plant specimens, including grasses ; botanical classification of Indian wheats and groundnut; species of grasses suitable for turfing embankments ; use of growth hormones ; examination of weed seeds in seed samples and germination tests on seed samples ; factors concerned in the preservation of germination capacity of seeds ; varieties of banana suitable for fibre extraction, methods of cultivation of crops, such as niger, safflower, cloves, black pepper, tapioca, etc.

Chemistry.—Methods of reclamation of saline and alkaline soils ; information on soil maps and on soil testing equipment ; analysis of soil samples and recommendation on fertiliser use on the basis of soil analysis ; information regarding the cowdung gas plant.

Soil and Land Use Survey.—Soil survey and land use reports, prepared on specific requests, for the Khamaria Military Farm, Jabalpur, the afforestation areas of Nanded Division in Bombay State, and the Sutlej (sub-catchment Svarghat) area in Himachal Pradesh.

Entomology.—Identification of insect specimens ; supply of coloured plates of Indian insect pests and useful birds; information on control of insect pests of agricultural and plantation crops and fruit trees.

Horticulture.—Supply of seed and other planting material of vegetable crops, fruit trees and ornamental flowers, especially roses, and information on the methods of their cultivation ;

advice on layouts of ornamental flower gardens, kitchen gardens, lawns and fruit orchards —especially to residents in and around Delhi and New Delhi.

Mycology.—Identification of diseased plant specimens, as also of fungal and bacterial cultures ; advice on control of plant diseases such as the *tundu* and the loose smut disease in wheat and seed borne diseases of barley, *jowar* and *bajra.*

(j) Land and Buildings

No land was acquired during the year. Construction work on eight DII—type quarters was completed, but the provision of electric connection to them is awaited.

The following construction works were in progress :—

1. The Assembly Hall.
2. Circular wall for the "Gamma Garden".
3. Four class rooms and seminar rooms for the Post-graduate School.
4. Residential quarters under the Second Five Year Plan.

Expenditure sanction was received from the Ministry of Works, Housing and Supply for the construction of a laboratory for the Wheat Breeding Sub-station at Indore (M.P.), but the construction work could not be taken up pending formal transfer of 20 acres of land for this purpose at the Institute of Plant Industry, Indore, by the Government of Madhya Pradesh.

The construction work on the following buildings could not be commenced as the expenditure sanction had yet to be accorded by the Ministry of Works, Housing and Supply :—

1. Cereal Research Laboratory.
2. Laboratory for Fundamental Plant Genetical Research.
3. Laboratory for the Division of Horticulture.
4. Administrative Wing of the Director's Office in connection with the establishment of the Post-graduate School.
5. Fumigatorium in the Division of Entomology.
6. Buildings at the new site of the Agricultural Research Sub-station, Karnal.
7. Soil Survey Laboratory at Bangalore.

Revised administrative approval and expenditure sanction were awaited from the Ministry of Food and Agriculture for the following construction works :—

1. Quarantine House for the Plant Introduction and Exploration Organisation.
2. Entrance gate and guard room.

(k) Accounts (Expenditure)

The total expenditure on the Institute and its sub-stations, during the financial year ended the 31st March 1959, amounted to Rs. 48,98,334, as per details given below :—

		Rs.
I.	(i) General expenditure on the Institute, including the Office of the Director, estate establishment and the I. A. I. Dispensary	8,05,812
	(ii) Division of Agronomy	6,11,718
	(iii) Statistics Section	28,656
	(iv) Agricultural Economics Section	18,646
	(v) Division of Agricultural Engineering	1,78,329
	(vi) Division of Botany	11,83,518
	(vii) Division of Entomology	3,31,214
	(viii) Division of Mycology and Plant Pathology	4,04,863
	(ix) Division of Soil Science and Agricultural Chemistry	9,42,585
	(x) Central College of Agricultural	1,16,827
	Total (I)	46,22,168
II.	*Experimental Farms*—	
	(i) Botanical Sub-station, Pusa (Bihar)	70,194
	(ii) Agricultural Research Sub-station, Karnal	1,54,166
	(iii) Central Vegetable Breeding Sub-station, Katrain	51,806
	Total (II)	2,76,166
	Total (I & II)	48,98,334

III. REPORTS OF THE HEADS OF DIVISIONS FOR 1958-59

REPORT OF THE DIVISION OF AGRONOMY

(Including Agricultural Research Substation, Karnal)

(*Dr. P. C. Raheja*)

I. Weather and its effects on crops

The weather data for the kharif and rabi, seasons, are reported as under :—

Season	Month	Temperatures °C				Rainfall in		Relative humidity at 7 a.m. local	Mean Velocity in km./hr.	Mean of hours bright sunshine	Mean evaporation in mm/day
		Mean Max.	Dep. from normal	Mean Min.	Dep. from normal	mms.	Dep. from normal				
Kharif	July '58	33.9	−1.2	26.8	−0.3	390.2	+175.3	82.4	8.5	4.3	9.1
	Aug. '58	32.3	−0.8	25.5	−0.3	209.8	+61.0	88.7	4.6	6.0	7.3
	Sept. '58	32.1	−1.3	24.6	−0.5	277.4	+176.8	89.3	7.3	5.5	6.3
Rabi	Oct. '58	30.7	−1.4	18.3	+0.8	23.1	−39.3	85.2	3.7	8.6	6.4
	Nov. '58	29.3	+1.9	9.9	+0.3	2.5	−0.3	84.3	3.0	9.5	4.0
	Dec. '58	17.8	−4.7	8.4	+2.0	1.3	−0.7	90.5	4.3	7.5	2.7
	January 59	19.5	−0.9	6.4	−0.3	67.8	+49.0	88.3	4.6	7.3	2.1
	February59	21.6	−1.8	8.0	+0.6	0.5	−13.2	82.1	6.4	9.1	3.8
	March 59	30.2	+0.8	13.2	−1.0	1.3	−22.8	72.8	5.7	9.1	6.7
	April 59	35.7	−0.5	18.0	−0.6	1.3	−5.5	45.5	4.7	8.5	9.7
	May 59	39.5	−0.5	23.1	−1.3	7.6	−1.1	41.7	7.2	10.3	13.9
	June 59	41.0	+0.9	27.9	+0.2	13.3	−16.3	51.0	8.3	8.3	15.8

The rainfall recorded during the year was 996.1 m.m. which was 358.3 m.m. above the normal. Excess rain during the monsoon season adversely affected the *kharif* crops, specially cotton and maize in the experiments. Early *rabi* crops were sown with September rainfall, while late *rabi* crops were sown with pre-soaking dose of irrigation. Rainfall of 67.8 m.m. during January benefitted the wheat and *rabi* crops, especially under *barani* conditions.

The yield of principle crops on the Agronomy Farm were as follows :—

Crops	1957-58 Average yield in mds./acre	1958-59 Average yield in mds./acre
Wheat	15·90	18·7
Oats	19·7	20·5
Peas	8·1	12·2
Gram	7·9	8·6
Berseem	469·3	356·7
Maize	17·6	10·9
Sugarcane	526·6	560·2
Potatoes	132·5	115·2
Tomatoes	111·7	112·7

Generally, the outturn of both *kharif* and *rabi* crops was normal.

II. Research Projects

The research programme of the Division is divided under the following sections :— (i) Soil fertility ; (ii) field crops ; (iii) vegetable and commercial crops ; (iv) farm and cattle management ; and (v) schemes on (a) All India fertilizer use ; (b) weed control ; (c) irrigation investigation ; (d) agricultural extension and (e) plant tissue tests and spray fertilization. The experimental results are detailed as under :—

Soil Fertility Section

1. *Permanent manurial experiment*

The experiment was started in *kharif* when maize and cotton were sown. In *rabi*, wheat and peas were raised to complete the rotation. Yield data were recorded and plant samples were collected for chemical analysis for study of the uptake of nutrients.

2. *Building up soil fertility through organic manures and inorganic fertilizers*

(i) *Organic manures and inorganic fertilizers in (a) cereal rotation ; (b) legume rotation.*—The rotations followed in the experiment are (a) Maize-wheat, (b) Maize-wheat-maize-peas.

The maize yields were poor due to water logged conditions caused by heavy rains. The wheat yields showed the effect of rotation and fertilizer treatments. The results confirm the beneficial effect of legume in rotation. The effects of all the manurial and fertilizer treatments were significant over control. As the manures were applied before the *kharif* sowing, the residual effect as estimated from the yields of wheat, proved to be significant over the control and the responses are comparable to the effects of fertilizer treatments of NP and NPK, the former treatment giving the highest yield of 25.08 mds. of wheat per acre.

(ii) *Effect of F.Y.M. and Ammonium sulphate on bajra, wheat, cowpeas and peas grown in various rotations.*—*Bajra* yielded significantly more in *bajra*-wheat ; and *bajra*-fallow rotations when compared to *bajra*-peas rotation. There was no effect of the application of F.Y.M. or fertilizers on *bajra* yield mainly because of lodging in case of higher doses of F.Y.M. and fertilizers. Application of 30 lb. N per acre in plots where residual effect of F.Y.M. is being evaluated gave the best response.

Application of 20 tons of F.Y.M. applied direct or 30 lb. N per acre applied in conjunction with F.Y.M. or applied to residual plots, increased the cowpeas yield significantly.

Wheat yields were significantly affected by rotations and application of F.Y.M. There was no difference in yield of wheat due to cowpea-wheat, and fallow-wheat rotations. The effect of F.Y.M. and 'split-up' application of fertilizers was found to be significant. When 30 lb. N/acre was applied in two doses, it gave the maximum yield. Peas yields were also significantly improved by the F.Y.M. and the nitrogen treatments over the control treatment.

(iii) *Organic manures, including green manure and inorganic fertilizers in wheat-maize-wheat rotation.*—This was the fifth cycle of the rotation. The results are presented in table I.

TABLE I

Treatments	Yield of wheat mds/acre
Main Plot—	
A. Control	16.42
B. Green Manuring (Guar)	19.39
C. Castor cake 60 lb. N/acre	20.75
D. F. Y. M. 60 lb. N/acre	18.71
S. Em.	±0.92
C. D. at 5%	2.77
Sub-plot treatments—	
Ist split—	
1. Control	15.93
2. Ammonium sulphate 40 lb N/acre	19.97
3. Superphosphate 80 lb. P_2O_5/acre	15.93
4. 40 lb. N.+80. lb. P_2O_5	21.27
5. 40 lb. N.+80 lb. P_2O_5+60 lb. K_2O.	20.99
S. Em	±0.73
C. D. at 5%	2.05
2nd split—(*Not applied to wheat*)—	
No control	16.92
N_1 20 lb. N.	20.72
S. Em.	±0.28
C. D. at 5%	0.79

The basal treatments of green manure, castor cake and F.Y.M. gave significantly higher yield than control treatment.

Application of 40 lb. N and 80 lb. P_2O_5 gave the maximum yield of 21.27 mds/acre as compared to 15.93 mds. in control.

There was no effect of phosphate applied alone or Potassium when applied in combination with N and P_2O_5. The yield of wheat was significantly higher in plots where 20 lb. N was applied to previous maize crop.

(iv) *Effect of water soluble silicate and F.Y.M. on soil productivity.*—There appeared to be no marked residual effect of the application of silicate or other treatments on the yield of maize or wheat crops. The difference in the yield of maize and wheat crop due to application of nitrogen over control was significant.

3. *Building up soil fertility through phosphate manuring of legumes*

(i) *Effect of low doses of phosphate on berseem and after effects on wheat.*—During the year, the residual effect of doses of organic and inorganic phosphate from the source of F.Y.M. and superphosphate applied to soil for berseem were studied on cowpeas/fallow-wheat crops.

TABLE II

Average yield in md. per acre.

Treatment per acre (to berseem)	Cowpea green fodder	Wheat C. 518		
		C.W.†	F.W.†	Average
A. F. Y. M. 16 lb. P_2O_5	106.6	13.55	20.05	16.80
B. F. Y. M. 32 lb. P_2O_5	178.2	17.71	28.20	22.96
C. F. Y. M. 64 lb. P_2O_5	148.2	25.79	24.94	25.36
D Super 16 lb. P_2O_5	165.1	17.12	21.41	19.26
E. Super 32 lb. P_2O_5	136.6	17.63	25.45	21.55
F. Super 64 lb. P_2O_5	148.6	25.00	25.75	25.38
G. Super 8 lb. P_2O_5+FYM 8 lb. P_2O_5	150.4	19.17	20.52	19.84
H. Super 8 lb. P_2O_5+FYM 24 lb. P_2O_5	125.6	16·80	20.49	18.64
I. Super 8 lb. P_2O_5+FYM 56 lb. P_2O_5	203.3	28.85	28.14	28.06
J. F.Y.M. 8 lb. P_2O_5+Super 24 lb. P_2O_5	173.9	23.20	25.49	24.34
K. F.Y.M. 8 lb. P_2O_5+Super 56 lb. P_2O_5	168.3	20.86	31.19	26.02
L. No manure	123.8	15.05	17.63	16.34
M. Fallow in *rabi* when berseem was grown	155.7	16.20	21.51	18.86
'F' test	Not sig.	Sig. 1%	Sig. 1%	Sig. 1%
S. Em.	±19.09	±1.90	±1.81	±1.47
C. D. 5%	..	5.54	5.29	4.16

* C. W.=Cowpea—Wheat; †F. W.=Fallow—Wheat.

There was no residual effect of P_2O_5 on the yield of cowpeas for fodder. There was a significant residual effect of higher doses of phosphate on wheat. In the fallow-wheat rotation the residual effect of phosphate on wheat was more pronounced than in the cowpea-wheat rotation.

The chemical analysis of soil from 0-9 at sowing showed that the percentage of organic carbon, and total nitrogen were high in plots treated with 64 lb. P_2O_5 as superphosphate or F.Y.M. or the combination of both, but C/N ratio was not changed appreciably. There was no visible effect of the treatments on the K_2O content of the soil.

(ii) *Effect of phosphate with and without potash and/or nitrogen on berseem and after effects on maize, cotton and wheat.*—The experiment was started in 1948-49, and three cycles of rotation were completed in 1956-57. Berseem was grown for second year in succession to study the residual effect of fertilizers.

Yield of berseem green fodder due to residual effect of phosphate application was significant in series II only. Application of nitrogen and potash exhibited no residual effect on berseem fodder.

4. *Phosphate manuring of legumes under rainfed conditions*

This was the second year of the trial. The results indicate that yield of *guar* green fodder increased significantly with increasing dose of phosphate over control. There was no residual effect of phosphate application to soil for *guar,* on the succeeding wheat crop. Higher yield of wheat was obtained by direct fertilization of wheat after fallow.

5. *Phosphobacterin inoculation of berseem and wheat seed and its effect on phosphate availability*

Phosphate was applied to berseem from different materials. The effect of Russian culture of phosphobacterin was studied in the absence and the presence of organic matter. The other cultures compared in the experiments without organic matter addition were FOSFO 24 and Indian cultures. Phosphate was applied at 60 lb. P_2O_5 per acre (Table III).

TABLE III

Yield of berseem green fodder in mds/acre 1958-59
(A/S at 30 lb. N was applied as a basal dressing.)

No	F.Y.M.	F.Y.M. at 30 lb. N.	F.Y.M.+ Super at 60 lb. P_2O_5	F.Y.M.+ Rock phosphate at 60 lb. P_2O_5	F.Y.N.+ Bonemeal at 60 lb. P_2O_5	Mean
1. No culture	835.5	928.9	1056.1	951.4	971.8	948.7
2. Phosphobacterin	1051.3	1062.9	1185.2	1080.0	1066.1	1089.0
3. Fosfo 24	961.8	951.1	1047.6	988.8	985.9	987.0
4. Indian culture	952.1	963.8	1054.7	971.1	973.3	982.9
Mean	950.1	976.7	1085.8	997.7	999.2	

'F' values significant for cultures, fertilizers and interaction.

	S. Em.±	C. D. at 5%
Cultures	10·74	29.8
Fertilizers	12·0	33.3
Interaction	24·02	66.6

Inoculation of berseem seed with phosphobacterin increased the yield of berseem fodder over the control (no culture). Of all the phosphatic fertilizers applied in conjunction with F.Y.M. ; only superphosphate increased the yield significantly over control treatment.

There was no residual effect of the cultures and the fertilizers applied to berseem, on the yield of wheat.

6. *Comparative studies on foliar and standard soil application methods of phosphatic fertilizer and micro-nutrients to peas and its residual effect on maize*

This was the first year of the experiment. The application of phosphate and different micronutrients and the various methods of application did not show any significant differences amongst the treatments on the grain yield of peas.

7. *Comparative effect of different systems of rotations*

This was the 8th year of the experiment, which has ten rotations of different cropping intensities including fallow and green manure.

The trend of results was the same as in previous years. Maize yields were low due to unfavourable weather conditions. The differences in yield of sugarcane, cotton and maize + cowpea for fodder crops were not significant.

The yield difference due to various rotations were very appreciable in this year than in the previous years. Peas yield was significantly lower in rotation G.M.—wheat—Maize—Peas; as compared to other rotations. There are three rotations in which potato has been included. Differences in potato yields of these rotations were significant. Berseem yields remained unaffected due to different rotation treatments.

Under continuous cropping, the wheat yields are decreasing since 1956-57. Cotton and maize yields were low due to climatic conditions and also due to fall in fertility level. Sugarcane yields were steady. The yields of crops in the Cowpea—Wheat rotation have been fluctuating. In case of Cotton—Wheat rotation the yield of both the crops were steady.

The studies on intensity of weed infestation indicated that different rotations have different intensities of weeds in various crops. The inclusion of soil cleaning crops of potato, sugarcane and berseem as well as fallow reduced the intensity of weeds in the succeeding crops.

8. *Barani rotations in relation to response to manures and fertilizers*

This was the third year of the experiment initiated on long term basis. It includes four crop rotations and six different manures and fertilizer treatments.

The effect of rotations on *bajra* yields was not significant. The application of 5 tons of F.Y.M., 15 lb. or 30 lb. N applied in combination with 20 lb. P_2O_5 increased the yield significantly over no manure treatment.

9. *Hubam clover as mixed crop in wheat-maize rotation*

This investigation was started in 1955-56 to assess the value of hubam clover as a mixed crop in wheat and its residual effect on maize. The results are reported in table IV.

TABLE IV

Av. yield of grain in md. per acre

Treatment per acre	Maize yellow No.2.	Wheat N.P. 718.
A. Wheat-fallow: no manure	..	13.23
B. Wheat-maize: 40 lb. N to wheat	4.63	23.52
C. Wheat-maize: 40 lb. N to maize	3.83	19.37
D. Wheat-maize : 40 lb. N to each crop	4.98	27.66
E. Wheat & Clover for fodder & G. M.—maize: no manure	5.15	13.10
F. Wheat & Clover-Maize; 40 lb N to maize.	3.71	16.44
G. Wheat & Clover-maize: 80 lb. P_2O_5 to clover	5.04	14.44
H. Wheat & Clover for G. M. only-maize: no manure	5.16	19.49
I. —do——maize: 40 lb. N to maize	4.49	20.69
J. —do— maize: 80 lb. P_2O_5 to clover	5.39	19.06
K. Hubam clover G.M. —Maize no manure	6.12	..
L. Wheat-Sann G.M. : no manure	..	20.53
'F' test	Not sig.	Sig. 1%
S.Em.	±0.52	±1.79
C. D. 5%	..	5.18

Maize crop was severely affected by waterlogging due to continuous heavy rains in early stage of growth, resulting in low yields. There were no treatment effects.

Wheat crop showed significant responses to treatments. Highest yield was obtained when both wheat and maize were fertilised with 40 lb. N/acre. Hubam clover when buried for green manuring without obtaining fodder gave higher yield of wheat than when one cutting of fodder was taken and the next cutting buried for green manure. Addition of P_2O_5 to wheat and hubam clover had no effect on the yield of wheat.

10. *Ley Farming experiment under rainfed conditions*

The investigation was started to study the residual effect of four grasses and normal *bajra*-gram ; and *jowar*-gram rotations on the yield of subsequent wheat crop under rainfed conditions. The results did not indicate any significant difference in yield of wheat grain in the first year after three years stand of the grass. However, wheat after *Panicum antidotale* gave the highest yield of 12.45 mds/acre as compared to 7.60 mds. after *Dichanthium annulatum*. Subsequent effect of ley is still under investigation.

11. *Six acre mixed farming holding*

Two units were laid out, one each under irrigated and rainfed conditions. The holdings completed three years during the year under report.

Under irrigated conditions, in general, the crop yields during the year were higher than those in previous years except in case of cotton, *jowar,* and *guar* which were adversely affected by heavy rains. The increase in yield of crop indicated a higher status of fertility built up by crop rotations and application of fertilizers doses applied in this unit.

Under rainfed conditions, the yield of *kharif* crops was poor on account of heavy rains during the growing period of these crops. The yield of *rabi* crops was higher than the corresponding yields obtained last year. Application of 30 lb. N+ 20 lb. P_2O_5 in conjunction with 5 tons of F.Y.M. increased the yield of jowar green fodder by 57.4 mds. per

acre over F.Y.M. alone. The application of 30 lb. N + 20 lb., P_2O_5 to wheat and *bajra* respectively gave an extra yield of 2.9 and 5.8 mds. per acre.

III-A. Field Crop Section

A. Fertilizer experiments

1. *Effect of F.Y.M. and ammonium sulphate at different levels on wheat*

This was the sixth year of the experiment. The growing of maize to study residual effect was discontinued. The results of direct effect of application of F.Y.M. and ammonium sulphate after summer fallow showed no significant effect on the yield of wheat. This may be due to fallow period. Although yield differences were not significant 120 N as F.Y.M. has shown the highest yield and continuous application of N as sulphate of ammonia has given lower yields. In the past, the application of 120 lb. N as F.Y.M. and 40 lb. N as sulphate of ammonia had given the highest comparable yields, which were significantly higher than the other treatments.

2. *Relative fertilizer value of dicalcium phosphate and superphosphate on wheat and maize*

This was the final year of the experiment. The two sources of phosphate showed no significant difference in the maize yield. But in case of wheat, the application of superphosphate to the soil proved superior to dicalcium phosphate.

3. *Relative efficiency of nitrogenous fertilizers under dry farming conditions*

The experiment was laid out to study the relative efficiency of different nitrogenous fertilizers on wheat. This was the third year of the trial under rainfed conditions.

The application of 15 lb. nitrogen over the basal dressing of 20 lb. P_2O_5/acre increased wheat yields by 3.3 mds. per acre. However, higher dose of nitrogen slightly reduced the wheat yield. Application of 20 lb. P_2O_5/acre alone increased wheat yield by 3.5 mds/acre over the control. The nitrogenous fertilizers ammonium sulphate, ammonium nitrate ammonium chloride, ammonium sulphate-nitrate and urea proved equally effective in increasing the yield of the wheat crop.

4. *Relative efficiency of nitromagnesia and other nitrogenous fertilizers on wheat*

This was the second year of the experiment. The results of the experiment conducted on wheat are presented below :—

Yield of wheat in mds./acre

Treatments	Yield
Sources of nitrogen—	
Ammonium sulphate	32·4
Ammonium nitrate	30·6
Nitro magnesia	30·5
Urea	32·0
S. Em.	±1·50
Levels of nitrogen—	
0 lb N/acre	22·7
20 lb N/acre	28·2
40 lb N/acre	33·6
60 lb N/acre	32·3
S. Em.	±1·30
C. D. 5%	3·73

Application of 20 and 40 lb. nitrogen per acre increased the wheat yield by 5.5 and 10.9 mds. per acre. The increase in wheat yield was significant. All nitrogenous fertilizers proved equally effective in maintaining the yield of wheat crop. The differences in outturn of wheat due to these fertilizers were not significant.

B. Cultural experiments

5. Optimum seed rate, spacing and date of sowing of wheat varieties NP 710 and NP 718.

The differences due to dates of sowing were significant. Sowing on 25th October and 12th November yielded significantly higher than the sowing on 1st December but there was no difference between the two earlier sowings. Spacing between rows at 9″ and 12″ yielded significantly more than 6″ spacing, but there was no difference between 9″ and 12″ spacing. There was no significant difference in yield due to 50, 70 and 90 lb. seed rates per acre. These results confirm the previous year's findings.

6. Tillage experiment under rainfed conditions on

(i) *Bajra.*—By deep cultivation with tractor plough (10″ deep) higher yield of *bajra* was obtained as compared to shallow cultivation with Victory plough (5″ and surface cultivation. Interculturing with bullocks and weeding with *khurpi* proved significantly beneficial to control (no weeding) treatment in improving the yield of the crop, but the two methods of interculturing showed no difference. Similar treatment effects were observed in the previous year.

(ii) *Wheat.*—Ploughing with the soil-inversion plough followed by country plough (5″ deep) gave the highest yield of wheat grain and more than tractor ploughing (10″ deep) and surface cultivation with harrow (2-4″ deep). Weeding with *khurpi* was found to be more effective as compared to no weeding or hoeing with bullocks. However the differences in wheat yield due to any of the two treatments were not significant.

C. Agrostology

7. Study of the technique of growing Hubam-wheat mixture

The investigation was started with the object of developing a technique with which the cultural operations could be carried out easily and the growth and development of wheat crop did not suffer by growing of hubam clover in conjunction with it. The treatments consisted of two dates of sowing, two methods of sowing and two seed rates. The two methods of sowing of hubam clover, by broadcast and in rows with wheat and the two seed rates of 10 and 15 lbs. per acre showed no significant difference in the yield of wheat or the hubam clover green fodder. Sowing on 5th November proved significantly superior to earlier sowing on 20th October.

8. Phosphate fertilization of velvet beans (Mucuna cochinchinensis) Rainfed

Velvet beans were sown in the first week of August. Different doses of phospate were applied at the time of sowing below the seed by drilling in the same row. The crop was harvested for green fodder in the last week of October. There was no significant increase in yield of fodder due to the application of phosphate, although the outturn of fodder increased corresponding to the increase in dose of phosphate applied to the soil.

9. Study of response of Linseed to NPK fertilizers

The application of nitrogen significantly increased the yield of linseed. Application of 30 lb. and 60 lb. nitrogen per acre increased the yield by 8.0 and 14.0 mds. per acre respectively over control (no nitrogen). The highest yield of 31.5 mds./acre was obtained with application of 60 lb. N+40 lb. K_2O per acre as compared to 16.0 mds. obtained in no fertilizer (control) treatment. It may thus be concluded that linseed pays handsomely by application of nitrogenous fertilizer upto 60 lb. N level.

10. *Cultural* cum *fertilizer Experiment on Paddy*

This was the second year of the experiment. The experiment was conducted to study the effect of spacing, nitrogen levels, method of fertilizer application and the cultural operations on the yield of paddy (Table V).

TABLE V

Response of paddy crop to various treatments

Treatments		Yield of Paddy in mds. /acre	S. Em.	C.D. at 5 %
Spacing	S_1=10″×10″	81.3	±1.14	3.41
	S_2=15″×6.67″	73.5		
	S_3=20″×5″	65.1		
Nitrogen levels	N_1=30 lb. N/acre	65.1	±1.14	3.41
	N_2=60 lb. N/acre	71.8		
	N_3=90 lb. N/acre	82.3		
Method of fertilizer application	B-Broadcast	69.1	±1.16	3.46
	P-Fertilizer placed 4″ below seedlings	77.5		
Cultural treatments.	E=Plant rows ridged	76.0	±0.42	1.19
	F=Crop matured on flat beds	70.6		

The spacing of 10″ between rows and 10″ between seedlings in the row gave the highest yield and significantly greater than the other two spacings. Increased doses of nitrogen increased the paddy yield progressively and consistently. Placement of fertilizer below the seedling gave higher yield of grain than broadcast application of nitrogen. Similarly ridging of plant rows proved significantly more beneficial in increased paddy yield than of the crop raised on flat beds. The results were in conformity with those obtained last year.

III-B. VEGETABLE AND COMMERCIAL CROP SECTION

A. Response to manures and fertilizers

(1) *Fertilizer N. P. K. experiment on Cauliflower*

This was the first year of the experiment. The effect of application of different doses of F.Y.M., nitrogen, phosphate and potash and their combinations were studied on the yield of Cauliflower. The results are presented in table IV.

TABLE IV

Average yield of Cauliflower heads in mds. per acre

Treatments	Yield in mds./ac.	Sig. by 'F' test	S. Em. ±	C.D. at. 5%	C.D. at. 1%
Nitrogen—					
N_0—No Ammonium Sulphate	129.53				
N_1—A/S @60 lb. N per acre	148.11				
N_2—A/S @120 lb. N per acre	162.41	1%	6.10	17.89	24.31
Phosphate—					
P_0—No Super	111.99				
P_1—Super @ 40 lb. P_2O_5/acre	156.82				
P_2—Super 80 lb. P_2O_5/acre	171.53	1%	6.10	17.89	24.31
K_2O—					
K_0—No Sulphate of potash	129.06				
K_1—Sulph. Pot. @ 40 lb. K2O/acre	150.43				
K_2—Sulph. 80 lb. K_2O/acre	160.57	Not Sig.	6.10		
F.Y.M.—					
F_1—F.Y.M. @2½ tons /acre	127.47				
F_2—F.Y.M. @5 tons /acre	160.46	1%	4.96	12.96	16.00

Application of 60 lb. and 120 lb. N per acre gave significantly higher yield of cauliflower heads, than the control (no nitrogen treatment), but there was no significant difference in yield due to 60 and 120 lb. N/acre levels. Application of 40 and 80 lb. P_2O_2 per acre increased the yield significantly but there was no significant difference in yield due to the two doses of phosphate. The application of 40 and 80 lb. K O did not increase the yields significantly over no potash treatment in spite substantial increase in yield of Cauliflower heads. The application of 5 tons of F.Y.M. proved significantly superior to 2.5 tons of F.Y.M. per acre. The interactions were not significant.

2. *Response of varieties of peas to fertilizer doses*

This was the third year of the experiment under rainfed conditions. The application of nitrogen or phosphate did not increase the yield of peas significantly. Peas Bonneville yielded significantly more than Peas N. P. 29 and Early badger. N. P. 29 also yielded significantly more than Early Badger.

The application of F.Y.M., nitrogen, phosphate and potash did not show any significant effect on the yield of peas under irrigated conditions. The two varieties of Peas N. P. 29 and Bonneville indicated small difference in yield of grain peas.

3. *Time of application of nitrogen doses and levels of phosphate on tomato*

This was the third year of experiments. The results are given in table V.

TABLE V

Average yield of tomato fruits in mds. per acre.

Treatments	Yield in mds./ac.	Sig. by 'F' test	S. Em. ±	C.D. at 5%
N_3O—Am Sulph. @30 lb. N per acre.	222.43	Sig.5%	8.98	26.32
N_6O—Am. Sulph. @60 lb. N. per acre	247.24	..	..	..
N_9O—Am. Sulph. @90 lb. N. per acre	260.53	..	..	..
P_2O-No super at 20 lb. P_2O_5/acre	278.43	Sig. 5%	8.98	26.32
P_4O—Super @40 lb. P_2O_5/acre	238.46	..	..	..
P_6O—Super @60 lb. P_2O_5/acre	268.30	..	..	..
Time of application of N—				
T_0—Full at planting	243.73	Not sig.	8.98	..
T_1—Half at planting ± half after 6 weeks	248.99	..	..	..
T_2—1/3 at planting ± 1/3 after 6 weeks ±1/3 at initiation of flowering.	242.47	..	..	..
N_0P_0—Control	216.26	..	15.47	34.3

The application of 60 and 90 lb. N yielded significantly higher than 30 lb. N per acre. There was no significant difference in yield due to 60 or 90 lb. N per acre. The different times of application of nitrogen manifested little effect on the yield of tomatoes.

5. *Comparative efficiency of various nitrogenous fertilizers in relation to production of onions*

This was the second year of the trial. The sources of nitrogen were ammonium sulphate, ammonium nitrate, ammonium chloride. The doses of fertilizers applied were 0, 60, 120, 180 and 240 lb. nitrogen. The application of different doses of nitrogen and different sources of fertilizers exhibited no significant difference on the yield of onions but all the levels of nitrogen yielded more than the control (no manure). The results were in conformity with that of last year.

6. Inter-relationship of varieties of sugarcane and nitrogen doses

The effect of different doses of nitrogen was studied on different varieties of sugarcane. The data are presented in table VI below :

TABLE VI

Relative performance of cane varieties in relation to doses of nitrogen

Treatment/Varieties	Yield of sugarcane in md/acre	S. Em. ±	C.D. at 5%
V_1—Co. 797	766.6	..	..
V_2—Co. 647	799.2	..	..
V_3—Co. 659	745.9	..	..
V_4—Co. 1109	878.2	..	..
V_5—Co. 999	706.4	..	..
V_6—Co. 998	651.9	28.40	85.58
Nitrogen levles—			
N_0—No manure	713.7		..
N_1—40 lbs. N.	743.4		..
N_2—80 lb. N.	779.4		..
N_3 120 lb. N.	795.7	16.69	47.32

The differences in yield amongst the varieties were significant. Variety Co. 1109 gave the highest yield of 878.2 mds. but it is not significantly greater than yield of the standard variety Co. 647. Application of 80 lb. N appeared to be optimum dose for sugarcane. The sucrose content was found to be highest (17.628) in sugarcane variety Co. 659 and 15.50 per cent in Co. 1109 which has given the highest yield.

IV. CATTLE BREEDING AND MANAGEMENT

1. Herd strength

The strength of the Sahiwal herd on June 30, 1959 was 106. The herd consisted of 47 cows, 3 stud bulls, 14 young male stock, 24 young female stock, 7 male calves and 11 female calves.

2. Milk yield

The wet and overall average for 1958-59 were 22.8 and 13.5 lb. respectively as against 21.8 and 12.3 lb. recorded last year. 31 cows completed their lactation during the year. Six cows yielded over 8000 lb. and 5 over 7000 lb. per lactation. The average total yield per day was 575.6 lb. The herd average per lactation was 6201.5 lb.

3. Calf rearing

36 calves were born during the year and 32 were transferred to young stock. 16 male calves were fed on standardized milk (3.5% fat) upto the age of one month and on skimmed

milk for 6 months. Such calves showed normal growth under this system of feeding. A saving of about 46 per cent in cost of rearing was affected by Skim milk feeding to the calves.

4. *Early maturity experiments*

Early matured heifers yielded 6511.5 lb. of milk on an average in the first lactation as against 5800.6 lb. yielded last year. Average at the first calving was 2 years, 9 months and 16 days.

5. *Artificial lactation in sterile cows*

One sterile cow, Afelbir was put on hormone treatment in inducing artificial lactation. The experiment was successfully carried out. Afelbir has completed 2 lactations in which she yielded 11220 lb. of milk.

V. Irrigation Investigation Scheme

1. *Relation between cropping patterns and irrigation intensities*

This project started in *rabi* 1955-56 with twelve 3-Course rotations of different cropping intensities varying from 100 to 200 per cent. The crops included in the rotations are maize, jowar cowpeas (fodder), sugarcane, cotton, potato, berseem and wheat.

Maize, sugarcane and cotton crops did not show any significant increase in yield due to irrigation levels in different rotations. *Jowar*+ cowpeas (fodder) following berseem yielded 315.0 mds. of green fodder per acre and significantly higher than after sugarcane or wheat yielding 256.0 and 245.0 mds. respectively. The effect of irrigation levels seems to have been marked by unprecedented rains during the growth period.

Potato crop showed no effect due to different levels of irrigations. The highest yield of 32.0 md./acre was obtained in case of wheat after fallow which was preceded by the potato crop in the rotation. Wheat yield of 27.21 mds. per acre was obtained after fallow preceded by sugarcane. There was no significant difference in yield of wheat due to 10 or 15 acre inches of irrigation. Berseem yielded significantly more when irrigated frequently (at low tensions). It also showed significant increase in yield when sown after maize as compared with yield of berseem sown after cotton.

2. *Inter-relationship of irrigation and fertilizer treatment on wheat*

This was the modification of the irrigation experiment conducted in the preceding three seasons. The effect of irrigation frequency (one, two and three irrigations) nitrogen levels (0, 30, 60 lb. N per acre) ; and phosphate and potash levels (P_0K_0, 40 lb. P_2O_5 and 40 lb. P_2O_5+40 lb. K_2O), was studied on wheat variety N. P 718.

The wheat crop on the average gave an out-turn of 34.0 mds. per acre though the wheat crop followed maize. Increased delta of irrigation increased the yield progressively but the differences were not significant. The effect of irrigation treatments seems to have been masked by the rainfall of 67.8 mm. received at heading stage which is the critical period for wheat.

Increase in the dose of nitrogen increased the yield of wheat significantly. Phosphatic and potassic fertilizers did not manifest any effect on grain yield of wheat.

3. *Interrelationship of varying water regimes and fertilizer doses on potato*

The effect of irrigations applied at three different soil moisture tensions, in combination with varying levels of nitrogen, phosphate and potassium was studied on potato crop variety, up-to-date. There was an average yield of 270 mds. of potatoes per acre. The yield was adversely affected by frost at the tuber development stage and the crop was harvested earlier by about 2 weeks. Frequent irrigations at low soil moisture tension increased the potato yield significantly as compared with delayed irrigation at higher soil moisture tensions. Application of different doses of nitrogen and phosphate showed no significant effect on the yield of potatoes probably due to frost effect. There was a significant increase in yield by the application of potassium sulphate at 75 lb. K_2O per acre over control. There was no further increase in yield when the does was increased to 150 lb. K_2O per acre. The well pronounced effect of potassium on yield was only evident in the presence of phosphate applied to the soil.

4. *Relationship of irrigation levels, nitrogen doses and seed rates on sugarcane*

The experiment was slightly modified during the year and conducted to study the relationship of different water regimes, nitrogen doses (50, 100 and 150 lb. N per acre) and seed rates (50, 75 and 100 mds./acre) on the yield of sugarcane variety Co. 647. The irrigations were applied at 0.3, 0.8 and above one atmosphere tensions. The seed rates were adjusted by increasing the number of rows per plot. The yield data are presented in the following table :

TABLE VII

Yield differences due to moisture tensions, nitrogen levels and seed rates of sugarcane

Delta of irrigation	Wt. of unstripped s. cane(md acre)	Sig. by 'F' test	S.Em. ±	C.D. at 5%
Delta of irrigation—				
I_0—20.0 acre inches	980·0	..	..	..
I_1—23.0 acre inches	1051·0	Sig.	11·39	32·4
I_2—35.0 acre inches	1144·0	..	..	..
Nitrogen per acre—				
N_1—50 lb.	994·0	..	..	..
N_2—100 lb.	1063·0	Sig.	11·39	32·4
N_3—150 lb.	1117·0	..	..	..
Seed rate per acre—				
S_1—50 mds.	1034·0	..	..	..
S_2—75 mds.	1057·0	Sig.	11·39	32·4
S_3—100 mds.	1084 0	..	..	..

Seasonal rainfall—37·3"

Irrigations applied more frequently at the lowest tension increased the yield progressively and significantly over the higher soil moisture tension treatments. Higher doses of nitrogen increased the yield significantly over lower doses of nitrogen. The dose of 150 lb. N/acre gave the highest yield. The increased seed rates showed higher yield but the increase in yield was absorbed by the extra seed used and as such did not appear to be economical.

The increasing levels of irrigation increased the evapo-transpiration ratio. Decreasing doses of nitrogen and seed rates progressivly reduced the E. T. ratio but the differences amongst the respective treatments were not significant. This is in conformity with last year's results.

5. *Influence of irrigation levels, nitrogen doses and sowing dates on cotton*

The experiment remained in progress for the third year. The differentiation in irrigation levels was brought about by irrigating cotton at three different soil moisture tensions. The cotton crop in general showed excessive vegetative growth and heavy flowering. Setting of bolls was low due to unfavourable climatic conditions, resulting in very low yields of the crop. None of the treatments except sowing dates showed significant effect. The unfavourable climatic conditions adversely affected the treatment effects.

Higher delta of irrigation increased the evapo-transpiration ratio significantly over low delta of irrigation. There was no effect of nitrogen doses on E. T. R. The delayed sowing reduced the E. T. R. but the differences were not significant amongst the treatments. This confirmed last years' results.

6. *Effect of frequency and levels of irrigation, nitrogen doses and phosphate levels on wheat*

This was the second year of the experiment. The frequency and the depth of irrigation showed on significant effect on the yield of wheat. The effects seem to have been masked by 67.8 mm. of rain received at the heading stage which is the critical period for wheat. Increasing doses of nitrogen increased the yield of wheat. The interaction between the phosphate applied last year and this year was significantly manifested on the yield of wheat over control treatment. 30 lb. P_2O applied this year showed the maximum yield of 39.00 mds. per acre, followed closely by 60 lb. P_2O_5 applied last year or 30 lb N + 30 lb. P_2O_5 applied in both the years.

7. *The interaction of irrigation frequency, method of irrigation, spacing and potassic fertilizer on wheat.*

This was the first year of the experiment. The experiment was designed to study the effect of irrigation levels, (one, two and three irrigations), methods of irrigation (flat, furrow early and furrow late) and the three spacings between lines (9.0 10.5 and 12.0" distance). The lowest delta of irrigation 4.5 acre inches produced high yield of 35:7 mds. per acre, which was significantly raised by increasing the delta of irrigation. The differences in yield due to methods of irrigation and spacing between lines were not significant.

8. *Relative efficiency of nitrogen doses and methods of irrigation on tobacco*

This was the second year of the experiment. The experiment involved 4 different soil moisture regimes ; 5 levels of nitrogen and 2 methods of irrigation. The results are given below :

Effect of soil moisture tension, method of irrigation and levels of nitrogen on yield of tobacco

Treatments	Yield in mds./ acre	Sig.by 'F' test	S.Em.	C.D. at.5%
Soil moisture tension—				
T_1—0.20-0.30 atmosphere	37·86	..	..	..
T_2—0.30-0.50 atmosphere	36·01	..	..	..
T_3—0.50-0.70 atmosphere	35·66	Sig.	±1·02	2·88
T_4—above one atmosphere	31·67	..	..	..
Nitrogen levels—				
N_0—0 lb. N.	26·72	..	..	..
N_1—40 lb. N.	31·69	Sig.	±0·80	2·37
N_2—80 lb. N.	37·37	..	..	..
N_3—120 lb. N.	39·34	..	..	..
N_4—160 lb. N.	41·10	..	..	..
Method of irrigation —				
M_1—Furrow method	35·01	..	..	..
M_2—Flat method	35·58	Not sig.	±0·51	..

More frequent irrigations at the lowest tension of 0.2—0.3 atmosphere gave the highest yield. The yield decreased progressively and consistently with increase in the interval of irrigation. Increased level of nitrogen progressively increased the yield of tobacco, the increase in yield followed the law of diminishing returns. There was no difference in yield due to different methods of irrigation. However, the furrow method of irrigation economised water as compared to flat bed method of irrigation.

9. *Influence of degree of tillage, irrigation intervals and nitrogen doses on sugarcane (Co. 647)*

This was the fifth and final year of the experiment. The yield data are shown in a table below :

Yield of cane in mds. per acre

Treatments	Cane yield mds./acre	Sig. by 'F' test	S. Em.	C.D. at 5%
Depth of Tillage—				
C_0—Desi ploughing 4-5" deep	754	Not. sig.	±4·49	..
C_1—Tractor ploughing 6" deep followed by grubbing and discing	760	..	..	..
C_2—Tractor ploughing 10" deep followed by grubbing and discing	757	..	..	..
Irrigation Interval—				
I_1—Irrigation after 10 days	649	Sig.	±8·81	24·84
I_2—Irrigation after 15 days	768	..	..	..
I_3—Irrigation after 20 days	771	..	..	..
Nitrogen Levels—				
N_1—Am. sulphate @ 80 lbs./N.	733	Sig.	±8·81	24·84
N_2—Am. sulphate @ 120 lbs. N.	746	..	..	..
N_3—Am. sulphate @ 160 lbs. N.	796	..	..	..

There was no significant difference on yield of sugarcane due to different depths of cultivation treatments. The yield of sugarcane increased significantly when the interval between irrigations was increased from 10 days to 20 days. Similarly increasing dose of nitrogen increased the yield significantly. This was contrary to expected results probably due to wet season. However, there was no difference in yield when the nitrogen dose was raised from 80 to 120 lb. N per acre.

10. *Differential response of wheat varieties to frequency of irrigation*

The wheat yield data are presented in table below :

Performance of nitrogen doses, frequency of irrigation and varieties

Varieties	Grain yield mds./acre	Sig. by. 'F' test	S.Em.	C.D. at 5%
V_1—N.P. 718	31·1	Sig. at	±0·63	1·77
V_2—N.P. 823	31·5	1%	..	..
V_3—N.P. 824	29·9	..	..	..
V_4—N.P. 828	19·8	..	..	..
Nitrogen doses—				
N_0—No manure	27·8	Not sig.	±0·63	..
N_1—20 lb. N.	27·2	..	..	..
N_2—40 lb. N.	29·0	..	..	..
N_3—80 lb. N.	28·2	..	..	..
Irrigation—				
I_1—One irrigation	28·5	Not sig.	±0·63	..
I_2—Two irrigations	27·3	..	..	..
I_3—Three irrigations	28·8	..	..	..
I_4—Four irrigations	27·7	..	..	..

There was no significant difference in yield between N. P. 718, N. P. 823 and N. P. 824 ; these varieties proved significantly superior to N. P. 828. In the previous year N. P. 824 had given outstanding performance. Application of different doses showed slight improvement in yield of wheat; 40 lb. N/acre gave the highest yield of wheat grain. The varying number of irrigations from one to four did not increase the yield significantly. The highest yield of 33·0 mds./acre was obtained with one irrigation in case of variety N.P. 718 and 32·6 mds./acre with three irrigations in case of variety N. P. 824.

VI. Weed Control Investigation Scheme

A. Control of Weeds in Crops

Weed control experiments conducted in various crops gave very interesting results. These are summarised in the succeeding text.

(a) *Wheat.*—2, 4-D applied in previous years to wheat field tended to reduce the weed population. The reduction of weeds was well marked in plots where post emergence application of 2, 4-D were given in previous years. Hand weeding and interculturing did

not show significant reduction in weed intensity. The treated plots yielded more wheat per acre as compared to control. However, the differences in grain yield were not significant.

In another experiment, where the weedicides were applied continuously for the third season, in the same plots, the effect of treatments on weeds was of the same order as in previous years. 2, 4-D at 8 oz. killed the broadleaved weeds completely. The weeds of *Melilotus* spp. were not completely eradicated by 8 oz. dose of weedicide. All weeds were completely eradicated with 1 lb. dose of 2, 4-D (a.e.) per acre. Application of ammonium sulphate in liquid form had very little effect in controlling weeds. Similarly cultivation proved a less effective means of weed control in wheat crop.

The data of wheat grain yield are given in table below :

Influence of doses of weedicides, number of intercultivations and doses of nitrogen on grain yield

Treatments	Grain yield mds. /acre	S.Em.	C.D. at 5%
Doses of 2,4-D Ester salt—			
0	19·0	±0·894	..
8 oz.	20·5	..	..
16 oz.	19·2	..	..
Number of Intercultivations—			
0	20·2	±0·894	..
1	19·4	..	..
2	19·1	..	..
Rate of application of nitrogen—			
0	16·4	±0·306	0·847
30 lb. N. (Solid A/S)	22·4	..	..
30 lb. N. (liquid A/S)	20·0	..	..

Data show that application of 2, 4-D or the number of intercultivations had no significant effect on wheat yield. The application of ammonium sulphate in solid form had better effect than liquid application and increased wheat yield significantly over control treatment. The application of 8 oz. 2, 4-D in conjunction with ammonium sulphate (solid) gave the highest wheat yield.

(b) *Peas.*—Two experiments were carried out to find out suitable weed control practices in peas. The effect of four weedicides; handweeding and hoeing was studied on weeds in the yield of peas. The effect of treatments on weeds was of the same order as in previous years.

The data are summarised as under :—

TABLE VIII

Influence of weedicides on control of weeds in peas

Treatments	Yield per acre	S.Em.	Sig. by. 'F' test	C.D. at 5%
1. Pre-emergence 2,4-D sodium salt	18·4	..	..	..
2. Pre-emergence 2,4-D butoxyethyl ester	20·4	..	..	..
3. Pre-emergence MCPA sodium salt	17·4	..	..	..
4. Pre-emergence MCPB sodium salt	18·6	±1·49	Sig.	4·31
5. Post-emergence 2,4-D sodium salt.	19·7	..	..	..
6. Post-emergence 2,4-D butoaxyethyl ester	13·9	..	..	..
7. Post-emergence MCPA sodium salt	17·8	..	..	..
8. Post-emergence MCPB sodium salt	24·2	..	..	..
9. Hoeing	21·2	..	..	..
10. Hand weeding	23·1	..	..	..
11. Control	18·9	..	..	..

Pre-emergence application of chemical weedicides has no beneficial effect on the yield of peas probably due to the germination of weeds after initial kill of some of them. Post-emergence application of sodium salt of 2, 4-D, ester of 2, 4-D and sodium salt of MCPA failed to increase the yield of peas in spite of the effective control of weeds. Toxic effect suppressed the growth of peas plants. On the other hand, MCPB significantly increased peas yield without any toxic effect on peas plants. Hand weeding was effective to the same extent as the application of MCPB weedicide.

In another experiment, application of MCPB and hoeing increased peas yield significantly over the control treatment. The application of ammonium sulphate in form of spray encouraged weed growth due to smothering effect on peas and lowered the yield as compared to control treatment.

(c) *Potatoes.*—Two experiments were conducted to standardise weed control in potatoes. In the first experiment the application of MCPA and 2, 4-D did not show any beneficial effect in the yield of potatoes. Early ridging in potato crop increased the yield of tubers significantly as compared to late ridging. In the second experiment, the application of MCPA at pre-sowing, pre-emergence, and pre-sowing+ pre-emergence did not significantly increase the yield of potatoes. Sowing on ridges followed by late earthing up recorded significant and well-marked improvement in the yield of potatoes. Furthermore, the pre-sowing application of MCPA in conjunction with potatoes planted on ridges followed by late earthing up showed the highest tuber yield of 301 mds./acre.

(d) *Sugarcane.*—The results of two experiments conducted on cane crop are given below :

(i) The effect of treatments on weed population and yield of sugarcane are tabulated as under :—

TABLE IX

Weed population and outturn of millable cane in relation to weed control treatments

Treatments	Weed Population per sq. yd.	Yield in mds./acre	Sig. by 'F' test	S.Em.	C. D. at 5%
A. Unweeded (control) . . .	216	659·8	..	..	..
B. Hoeing by bullocks . . .	67	927·9	..	..	..
C. Pre-emergence 2,4-D 2 lb. . .	87	695·8	..	..	..
D. Post-emergence 2,4-D 2 lb. . .	93	823·0	..	..	..
E. Post-emergence 2,4-D 2 lb. . .	120	818·0	..	..	..
F. Pre-emergence 2,4-D+Post emergence 2,4-D—2 lbs.	55	830·5	Sig.	41·89	121·91
G. Pre-emergence 2,4-D+ hoeing by bullocks.	34	943·4	..	..	..
H. Post-emergence Do. . .	49	897·0	..	..	..
I. Pre-emergence 2,4-D+post emergence 2,4-D 2 lbs. + hoeings.	20	978·4	..	..	..
Weed population per sq. yd. . .	..	..	Sig.	11·69	34·02

All the cultural or chemical weed control treatments significantly reduced the number of weeds in the crop. The best results were obtained by use of chemical weedicide in combination with cultural practices.

The treatments which gave best weed control also gave the highest yield of sugarcane. Hoeing by bullock proved quite effective.

In another experiment, *Cyperus rotundus* and *Cynodon dactylon* were partially controlled by the application of 2, 4-D and TCA respectively. Broadleaved weeds were reduced by the application of 2, 4-D, TCA and PCP to the same degree.

The effect of treatments on the yield of sugarcane is shown in the following table :

TABLE X

Effectiveness of Chemical & Cultural practices on yield of sugarcane

Treatments			Yield of cane mds/acre			Sig. by 'F' test	S.Em.	C.D. at 5%
			Pre-emergence application of weedicides					
			2,4-D 2 lb.	TCA. 10 lb.	PCP. 5 lb.			
Pre-emergence	*Post -emergence I*	*Post II—*						
1. 2,4-D 2 lb.	One hoeing	..	601	753	607	..	..	..
2. Do.	One hoeing	One hoeing	601	640	601	..	..	..
3. Do.	2,4-D 2 lb.	..	563	634	510	..	..	..
4. Do.	2,4-D 2 lb.	One hoeing	582	673	555	..	..	..
5 Do.	TCA 10 lb.	..	532	746	525	..	..	..
6. Do.	TCA 10 lb.	One hoeing	605	548	604	Sig.	±62·2	186·7
7. Do.	PCP 5 lb.	..	605	628	527	..	± ..	..
8. Do.	PCP 5 lb.	One hoeing	596	688	654	..	..	..
9. Local method (control)		..	543	..	..	..	..	..
10. Hand weeding		..	960	..	..	..	..	..

The pre-emergence application of TCA proved superior to application of 2, 4-D or PCP over the local methods. The post emergence application of TCA or one cultivation with pre-emergence with TAC has given significantly higher yield to local method. All other treatments showed no significant superiority over control treatment. Hand weeding regularly 8 times during the crop season has given 417 mds. (77%) more yield than the local control. This proved most expensive of all the treatments.

(e) *Bajra.*—The experiment was conducted to evaluate the effect of various cultural and chemical treatments on weed control in *bajra* crop and their effect on its

yield. Post-emergence application of 2, 4-D proved superior to pre-emergence application in controlling weeds. The *bajra* yields were better in all the treated plots than control, however, the differences were not significant amongst the chemical and cultural weed control treatments.

(f) *Maize.*—The experiment was conducted to study the effect of different phenoxy type herbicides namely, MCPA, 2, 4-D and MCPB in controlling weeds in maize. Post-emergence application of herbicides caused efficient weed control of broadleaved weeds and particularly *Justicia quinquinangularis,* a dominant weed in maize. However the growth of grasses was stimulated in chemical-treated plots. Hand-weeding and hoeing increased the maize yields significantly over control while the application of herbicides showed no increase in yield of maize.

(g) *Cotton.*—Application of TCA, PCP and low doses of 2, 4-D proved ineffective in the control of *Cyperus rotundus* (motha) in cotton which smothered the crop resulting in poor growth. Satisfactory weed control was obtained with hand-weeding. The yield of cotton showed high correlation with the degree of weed infestation and consequently weed control in the crop.

B. Control of perennial weeds

Experimental work remained in progress on control of perennial weeds. The two serious ones are *Sorghum halepense and Carthamus oxyacantha.*

1. *Control of Sorghum halepense* (*Baru*)

To confirm the results of experiments conducted here during 1956-57 and 1957-58 an experiment was laid out at the Agricultural Research Sub-station, Karnal to study the effect of application of different doses of TCA and cultivation treatments on *Sorghum halepense* and subsequently on improvement in yield of wheat crop.

The data indicated the significant beneficial effect of TCA and cultivations on controlling this serious weed. Application of TCA at 30 and 60 lb. per acre in conjunction with six cultivations eradicated the weed completely. The yield of wheat showed high correlation with the degree of weed control. As compared to control plot yield of 3·9 mds. the highest yield obtained was 12·8 mds. with six tillage operations and 30 lb. TCA.

2. *Control of Carthamus oxyacantha* (*Pohli*)

Carthamus oxyacantha, an abnoxious weed in wheat crop was effectively controlled by the application of sodium salt of 2, 4-D at 1 lb. acid equivalent per acre, applied six weeks after sowing of the crop. There was no injury due to the application of the chemical to the wheat crop. In case of sensitive crops like gram, mustard, etc., where the chemical could not be applied at post-emergence stage, the weed was effectively controlled by the spray of 2, 4-D at 1·5 lb. acid equivalent, immediately after the harvest of the crop.

VII. Plant Tissue Test and Spray Fertilization Scheme

(A) *Foliar Spray Experiments*

1. *Spray Fertilization trial on tomato*

This was the second year of the experiment. The results are presented in the following table.

Table XI

Tomato Yield trials mds/acre

Treatments	Soil application	Spray application & 4% concentration	Spray application & 2% concentration
1. Control	169·7	..	..
2. 30 lb N/acre	254·5	238·6	261·6
3. 60 lb N/acre	284·1	175·3	211·0
4. 120 lb N/acre	265·5	..	..
5. 20 lb. P_2O_5/acre	234·0	..	292·3
6. 40 lb P_2O_5/acre	224·3	..	196·7
7. 30 lb N + 20 lb P_2O_5/acre	234·8	278·2	..
8. 30 lb N + 40 lb. P_2O_5/acre	231·7	318·6	..
9. 60 lb N + 20 lb. P_2O_5/acre	238·9	203·0	..
10. 60 lb N. + 40 lb P_2O_5/acre	302·9	191·9	..
11. 120 lb. N + 20 lb. P_2O_5/acre	284·3	..	..
12. 120. lb. N + 40 lb. P_2O_5/acre	359·4	..	..

Application of nitrogen in the form of urea and phosphorous in the form of triple superphosphate increased substantially the yields of tomato. The highest yield of 359 mds, per acre was obtained with soil application of 120 lb. N+40 lb. P_2O_5 per acre, while with the foliar application of 30 lb. N+40 lbs. P_2O_5, the yield of 3186 mds. was obtained, against the yield of 169·7 mds. from the control plot.

2. *Comparative efficiency of spray and soil application of phosphate, and micro-nutrients on gram yield under rainfed conditions and on pea under irrigated conditions*

The application of 40 lb. P O per acre as soil application or as sprays or the application of micro-nutrients with phosphate showed no increase in the yield of grain under rainfed conditions.

Similarly, application of 40 lb. P_2O_5 either alone or in combination with micro-nutrients did not increase the Peas yield. Plant tissue tests indicated absorption of sprayed phosphate by leaves.

3. *Spray fertilization of cotton*

The experiment was conducted for the first year. The treatments consisted of application of different levels of nitrogen and phosphate, applied as soil or spray application. The application of different doses of nitrogen or phosphate or the methods of application showed no significant effect on the yield of cotton under irrigated conditions.

4. Spray fertilization of berseem

The experiment was conducted to study the effect of phosphorus and other micro-nutrients on the yield of berseem fodder when applied through soil or in sprays. The results are presented in table below :—

TABLE XII

Treatments	Berseem yield md/acre	Sig. by 'F' test	S. Em.	CD.5%
1. Control	578·88	..	..	..
2. 60 lb. P_2O_5 /acre	797·86	..	..	..
3. 120 lb P_2O_5/acre	812·37	..	..	..
4. 40 lb P_2O_5 (Soil application) +20 lb P_2O_5 (Spryed four times)	818·18	..	..	..
5. 80 lb. P_2O_5 (soil application) +40 lb P_2O_5 (sprayed four times)	828·46	..	..	..
6. 40 lb. P_2O_5 /acre (sprayed 4 times)	710·75	..	..	..
7. 60 lb. P_2O_5 + 1 lb. Mo. (Soil application)	820·47	Sig. at 1%	+42·92 —	121·83
8. 60 lb. P_2O_5 + 1 lb. B. (Soil application)	855·92	..	..	..
9. 60 lb. P_2O_5+ 2 lb. Zn. (Soil application)	815·39	..	..	..
10. 120 1 lb. P_2O_5+lb. Mo. (Soil application)	835·72	..	..	..
11. 120 lb. P_2O_5+ 1 lb. B. (Soil application)	870·44	..	..	..
12. 120 lb. P_2O_5+ 2 lb. Zn. (Soil application)	864·60	..	..	..
13. 60 lb. P_2O_5(soil application)+2 lb. Mo (sprayed four times)	772·81	..	..	..
14. 60 lb. P_2O_5(soil application) + 2 lb. Mo. (sprayed four times)	693·81	..	..	..
15. 60 lb. P_2O_5 (soil application) + 1 lb. Zn. (sprayed four times)	833·54	..	..	..
16. 120 lb. P_2O_5 (soil application) + ½ lb Mo. (sprayed four times)	840·80	..	..	..
17. 120 lb. P_2O_5 (soil application) + ½ lb. B (sprayed four times)	840·56	..	..	..
18. 120 lb. P_2O_5 (soil application) + 1 lb. Zn. (sprayed four times)	927·30	..	..	..

Application of phosphate either alone or with micro-nutrients increased the fodder yield significantly over control treatment. The maximum yield of 927.3 mds. per acre

was obtained by application of 120 lb. P O_5(soil applied)+one lb. of zinc sprayed four times. This gave the additional response of 348.4 mds. against the response of 233.4 mds with 120 lb. P_2O_5 applied alone.

B. Coordinated Agronomic Experiments

1. *Phosphate fertilizer placement on wheat*

The experiment was conducted to study the effect of different sources of phosphate, phosphate doses and their method of application on wheat. Between the sources of phosphate, superphosphate and ammonium phosphate proved equally effective. There was no response to doses of P_2O_5 or the method of application of phosphate to the soil. Application of 30 lb. N/acre increased the wheat yield by 9.08 mds. per acre significantly over control.

2. *Efficiency of nitrogenous fertilizers on wheat production*

The experiment was laid out to study the relative efficiency of five nitrogenous fertilizers applied at the rate of 20, 40 and 60 lb. N per acre. The data are presented in the following table.

TABLE XIII

Relative response to nitrogenous fertilizer at various levels on wheat

Treatments	Yield Mds/acre	Sig. by. 'F' test	S. Em.	C.D. at 5%
Sources of Nitrogen—				
Ammonium sulphate	25·39	..	..	..
Ammonium sulphate nitrate	22·50	..	..	..
Ammonium chloride	24·44	Sig.	±0·4	1·16
Ammonium nitrate	26·15	..	..	..
Urea	23·90	..	..	..
Levels of Nitrogen—				
0 lb. N/acre	20·05	..	..	..
20 lb N/acre	22·10	..	..	..
40 lb N/acre	24·29	Sig.	±0·31	0·90
60 lb N/acre	27·05	..	..	..

Ammonium nitrate proved most efficient carrier of nitrogen while ammonium sulphate nitrate and Urea gave slightly lower responses compared to other three nitrogenous fertilizers. Ammonium nitrate and ammonium sulphate proved equally effective in increasing yield of wheat crop. Increasing doses of nitrogen increased the wheat yield significantly over control.

3. *N. P. K. experiments*

The effect of different doses of nitrogen, phosphorus and potash on wheat varieties N. P. 718 and N. P. 710 has been studied. The results are presented below in table

TABLE XIV

Wheat yield of N. P. 710 and N. P. 718 with levels of N, P, K.

(Yield in mds/acre)

Fertilizer doses/acre.	N.P. 710	N.P. 718	Mean of two varieties
0 lb. N	16·04	17·44	16·73
20 lb. N	22·19	25·74	23·96
40 lb. N	26·83	31·17	29·00
0 lb. P_2O_5	22·94	24·46	23·70
20 lb. P_2O_5	20·99	24·86	22·92
40 lb. P_2O_5	21·11	25·03	23·07
0 lb. K_2O	21·28	24·60	22·94
20 lb. K_2O	22·18	25·10	23·64
40 lb. K_2O	21·60	24·65	23·12
Yield of wheat varieites*	21·65	24·78	..

* Average over all fertilizer treatments.

Wheat variety N. P. 718 gave better yield than N. P. 710 and the extra yield being of the order of 3.13 mds./acre. Among the major nutrients, the response to doses of nitrogen was very pronounced while responses to doses of P_2O_5 and KO were poor. N. P. 718 responded better to nitrogen application compared to N. P. 710.

VIII. Model Agronomic Experiment Scheme, ICAR

Under this ICAR scheme, complex manurial, cultural, rotational and irrigational experiments are conducted at selected centres in the various agro-climatic regions of the country, with the following objectives :—

1. Response of various crops to different nitrogenous, phosphatic and potassic fertilizers ;
5. Inter-relationship of fertilizers to cultural practices, such as dates of sowing or
3. Irrigation requirements of major crops, particularly in the areas to be served by the new river valley projects ;
4. Methods of placement and best time of application of fertilizers ;
5. Inter-relationship of fertilizers to cultural practices, such as dates of sowing or planting, seedrates, spacing of plants etc. ;
6. Effect of manuring in relation to rotation of crops ; and
7. Residual and long term effects of application of fertilizers and manures separately as well as in combination.

During 1958-59 experiments were conducted on paddy, wheat, *jowar*, maize, cotton an oilseed of local importance and legumes in rotation. Experiments conducted on various crops during *kharif* and *rabi* 1958-59 are given below.

Crop experiments conducted during 1958-59

Name of crop	No. of Experiments conducted	Name of centres /States
Paddy. . . .	68	Chinnegonchal (A.P.); Chalvai (A.P.); Maruteru (A.P.); Tinsukhia (Assam); Sabour (Bihar); Karjat (B.S.); Karomana (Kerala); Bhagwai (M.P.); Satna (M.P.); Raipur (M.P.); Aduthurai (Madras); Shimoga (Mysore); Kendrapara (Orissa); Barapalli (Orissa) Nasirpur (Punjab); Burdwan and Mandkhanda (W.B.).
Wheat . . .	66	Chalvai (A.P.); Umrala (B.S.); Lakhampur (B.S.); Bhagvai (M.P.); Ujjain (M.P.); Obedullaganj (M.P.) Powerkheda (M.P.); Satna (M.P.); Gangavati (Mysore); Barapali (Orissa); Sri Ganganagar (Rajasthan); Nasirpur (Punjab); Sirsa (Punjab); Kanpur, Varanasi & Bichhpuri (U.P.).
Legumes . . .	14	Chalvai (A.P.); Tinsukia (Assam); Sabour (Bihar); Umrala (B.S.); Lakhmapur (B.S.); Obedullaganj (M.P.); Powerkheda (M.P.); Gangavati (Mysore); Shimoga (Mysore); Nasirpur (Punjab); Varanasi, Kanpur & Bichhpuri (U.P).
Cotton . . .	13	Umrala (B.S.); Akola (B.S.); Ujjain (M.P.); Bhavanisagar (Madras); Gangavati (Mysore); Barapalli (Orissa); Sirsa (Punjab); Bichpuri (U.P.).
Jowar . . .	12	Umrala (B.S.); Akola (B.S.); Ujjain (M.P.); Bhavanisagar (Madras); Gangavati (Mysore).
Groundnut . . .	1	Gangavati (Mysore).
Sugarcane . . .	1	Bhagvai (M.P.).
Maize . . .	5	Barapalli (Orissa); Nasirpur (Punjab); Varanasi and Kanpur (U.P.).
TOTAL . . .	180	

Thus, during 1958-59; 180 factorial experiments were conducted at 30 centres. Thus, at each centre, on an average, 6 experiments were conducted during both the seasons. Under the scheme, 102 experiments were conducted during *kharif* and 78 experiments during *rabi* season.

The distribution of experiments on various crops is given as under :—

Type of Experiment	Crop wise distribution of experiments								
	Paddy.	Wheat	Ground	Jowar	Maize	Legumes.	S. cane	Cotton	Total
1. Irrigation-*cum*-manuring	..	9	..	..	..	..	..	..	9
2. Manuring of Crop rotation	15	7	1	1	1	..	1	4	30
3. Manuring of fixed crop rotation.	3	6	..	..	..	2	..	2	13
4. Phosphate manuring of legumes	6	11	..	..	..	13	..	..	30
5. Time of application of nitrogenous fert.	16	7	..	3	..	..	..	5	31
6. Placement of fertilisers	9	10	..	2	..	..	..	..	21
7. Cultural-*cum*-manuring paddy	9	..	..	..	..	..	..	..	9
8. Cultural-*cum*-manuring on other crops.	..	12	..	5	2	..	..	2	21
9. TCM-Direct residual & cumulative effect of phosphate.	9	4	..	1	2	..	..	..	16

At majority of the centres, experiment No. 2 (manuring of crop rotation), 4 (phosphate manuring of legumes and its after effect on cereal), 5 (time of application of nitrogenous fertilizers), 6 (placement of fertilizers) and 7 & 8 (cultural *cum* manuring) were conducted on various crops. Irrigation experiment was conducted on wheat at 9 centres, while direct residual and cumulative effect of phosphate fertilization was studied at 16 centres on yield of various crops.

IX. Coordinated scheme of simple fertilizer trials on cultivators' fields

The scheme has been initiated by the Indian Council of Agricultural Research, New Delhi with the following objectives :—

1. Reponses to nitrogen, phosphate and potash and their interaction;
2. Relative value of nitrogenous fertilizers, namely ammonium sulphate, urea, ammonium sulphate nitrate, calcium ammonium nitrate and other nitrogenous fertilizers that may be manufactured in the country;
3. Phosphate respone to legumes and its residual value on succeeding crop;
4. Relative value of dicalcium phosphate and superphosphate ; and
5. Correlation of fertility status of soil with crop response.

With these objectives in view, four types of simple fertilizer trials are being conducted on cultivators' fields in the irrigated or assured rainfall areas (35 inches or above) of the country. These types of experiments are given below :—

(a) O, N, P, NP, K, NK, PK, NPK (with N in the form of ammonium sulphate, P in the form of superphosphate and K in the form of muriate of potash).

(b) O, N_1, N_2, N'_1, N'_2, N''_1, N_2'' (with ammonium sulphate (N) and any two of the three nitrogenous fertilizers namely, urea, ammonium sulphate-nitrate and calcium ammonium nitrate expressed as N′ and N″).

(c) O, P_1, P_2 P'_1, P'_2 (on legumes only with superphosphate (P) and dicalcium phosphate (P″) at two levels each).

(d) V_1O, V_1NPK, V_2O, V_2NPK, V_3O, V_3NPK (on *jute* only with three varieties V_1, V , and ammonium sulphate, superphosphate and muriate of potash).

These experiments were conducted in the states of Andhra Pradesh, Assam, Bihar, Bombay, Himachal Pradesh, Jammu & Kashmir, Kerala, Madhya Pradesh, Madras, Mysore, Orissa, Rajasthan, Punjab, Uttar Pradesh and West Bengal. The details of the work carried out in these States are given below :—

The number of experiments conducted in various states

Name of State	Date of starting the scheme	No. of centres	N. of. experiments conducted	Principal crops
Andhra Pradesh	Sept., 1958	10	464	Paddy, Jute, sugarcane.
Assam	July, 1958	8	63	Mustard and legumes.
Bihar	Oct., 1958	11	944	Paddy, sugarcane, jute, pulses, mustard, wheat, Patotato.
Himachal Pradesh	Sept., 1958	3	110	Wheat, potato.
Kerala	Sept., 1957	3	96	Paddy.
M.P.	March, 1956	2	70	Wheat, maize, cotton, jowar, groundunut.
Mysore	May, 1958	12	425	Paddy, jowar, ragi, sugarcane potato, cotton, pulses.
Orissa	July, 1957	9	632	Paddy, jute, sugarcane, ragi, wheat, potato, pulses, cotton.
Rajasthan	May, 1958	2	210	Wheat, paddy, sugarcane, oil-seeds.
Punjab	May, 1958	6	764	Sugarcane, cotton, maize, paddy, bajra, wheat, potato, oilseeds and pulses.
U.P.	Sept., 1958	18	859	
West Bengal	May, 1958	10	410	Paddy, jute, oilseeds, pulses.

The scheme had covered during 1958-59, 94 districts of the country where 4,984 simple fertilizer trials had been conducted. The data are being compiled.

X 1. *Agricultural Economics*

The work on the Project on Farm Planning and Budgeting studies was started in 8 villages of the I. A. R. I., Intensive Cultivation Scheme Block. The following studies were initiated under the project :

1. Pilot studies of research available for agricultural production ;
2. Estimates of marketable surplus of agricultural production ;
3. Study of farm budgets in cultivators' holdings ;
4. Farm Planning & Budgeting on Cultivators holdings ; and
5. Studies in cultivation of crops on cultivators' holdings.

The studies 1 and 2 above were completed and 3, 4 and 5 are in progress. Under item 5, information on the cost of cultivation of *rabi* crops was collected and processed. The results of the studies are given as under :—

2. *Resources available for agricultural production*

In table XV data on "livelihood classes" of the population are summarised.

TABLE XV

Distribution of population by "livelihood classes" in the villages

Livelihood classes	Persons	% of total
1. Cultivators of land wholly or mainly owned	4595	48·52
2. Cultivators of land wholly or mainly unowned	276	2·91
3. Cultivating labourers	703	7·42
4. Non-cultivating owners of land agrl. rent receivers	195	2·06
TOTAL AGRICULTURAL CLASSES.	5769	60·91
5. Production other than cultivation	897	9·47
6. Commerce	248	2·62
7. Transport	66	0·70
8. Others—including domestic service and misc.	2491	26·30
TOTAL NON-AGRICULTURAL CLASSES	3702	39·09
GRAND TOTAL	9471	100·00

The percentage under different livelihood classes for the selected villages show the marked impact of urbanisation due to the proximity of their villages to Delhi Metropolitan area. The non-agricultural population is much higher than the corresponding national figure. In the agricultural sector, the owner cultivator class is comparatively more dominant than cultivating labourers and others.

The second resource for which data were compiled is the available labour supply.

Table XVI

Size of family and estimates of available labour supply for different size groups of holding

Size of holding group.	Mean size (acres)	Mean size of family				*Estimated available labour supply in terms of male adults days per-year.	
		Adults		Children	Total		
		Male	Female			per-holding	per acre
Less than 5 ac.	3·69	1·93	1·86	3·07	6·86	486·2	131·8
5 to 10 acres .	7·60	3·44	3·06	4·62	11·12	416·5	54·8
10 to 15 acres .	11·76	2·79	3·07	4·43	10·29	420·0	35·7
15 acres & above	24·57	3·19	2·57	3·69	9·66	467·2	19·0

*Child and female labour have been converted into male adult labour equivalent on the basis of 1c=½/m=and 1W=3/4 m.

The holdings of the three larger sizes are associated more with the traditional joint family system involving a larger number of females and children. As regards, labour supply, irrespective of the size of holding, between 200 to 229 adult man days, in addition to female and child labour, per year are available to the farm. It has also been observed that the available family labour supply per acre decreases as the size of holding increases.

The estimates of material assets of the farmers were also evaluated. These data are given below :—

Table XVII

Estimate average values of buildings, implements and livestock owned

Size of holding groups	Buildings		Implements estimated value	
	Number	Values	per holding	per acre
		Rs.	Rs.	Rs.
Less than 5 ac.	1·57	6342·8	468·9	127·0
5 to 10 acres	2·12	12662·5	972·6	128·0
10 to 15 acres	1·86	17300·0	1179·8	107·8
15 acres & above	2·19	20287·5	2300·0	93·6

TABLE XVII (*Contd.*)

Estimate average values of buildings, implements and livestock owned (contd.)

Size of holding groups	Livestock							Total Estimated value per holding
	Draught cattle			Milk cattle		Misc.		
	per holding unit	per acre unit	Value	Unit	Value.	Units	Value	
			Rs.		Rs.		Rs.	
Less than 5 ac. .	1·71	0·46	548·9	1·78	551·8	0·85	111·8	1212·5
5-10 acres . .	1·81	0·23	831·3	2·43	721·9	1·87	259·1	1812·2
10-15 acres . .	1·86	0·17	846·8	2·50	907·5	1·71	340·0	2094·3
15 acres & above .	2·62	0·11	1384·1	2·17	873·8	1·44	471·3	2729·1

The investment in buildings, implements and livestock, as indicated by their estimated average values, increases with an increase in the size of holding. However, the investment per acre on implements (but for the size group 5—10 acres) and draught cattle shows a reverse trend, which may be construed to imply that these factors of production are put to more and more intensive use as the size of holding, increases and thus result in the economics of scale.

Assets and liabilities of the farmers were also assessed. These are summarised in the following table :—

TABLE XVIII

Estimated financial position (assets and liabilities)

(Per famialy Rs.)

Size of holding group	Assets (including cash at hand and shares owned) in crops	Liabilities					
		Total	Loans from			%wise classifications of loans	
			Cultivators	Coops.	Govt.	Productive	Unproductive
Less than 5 ac.	292·0	480·7	373·6	57·1	50·0	50·7	49·3
5 to 10 acres .	271·9	884·4	437·5	109·4	337·5	45·6	54·4
10 to 15 acres .	1965·1	317·8	128·5	46·4	142·9	59·5	40·5
15 acres & above	6581·2	125·0	..	125·0	..	100·0	..

Only a small part of the assets is kept with the institutional agencies, whereas the major portion is kept either in liquid form or is loaned out. On the liability side, the contribution of co-operative societies is not very encouraging. It is only in the case of

largest size holding group that the cent per cent liabilities are owned to the cooperati societies. The contribution of the State Government in the form of *taccavi* loans is qui substantial and this is the cheapest source of credit to the cultivators. Quite a substanti portion of liabilities has been incurred for unproductive purposes, and percentage varyin from 40:5 to 54:4 per cent.

Marketable surplus of agricultural production.—For both kharif and rabi crops th surplus, produce was estimated. These data for different sized holding is given in table :—

TABLE XIX

Farmers estimates of their annual marketable surplus (mds.)

Size of holding Groups	Cereals			Pulses	Fodder	Livestock products	
	Khrif	Rabi	Total			Milk	Ghe
Less than 5 ac. .	1·77	14·21	12·44	—23·62	—141·90	32·39	0·0
5 tol 10. . .	3·42	31·02	34·44	—31·75	—104·49	4·02	0·1
10-15 ac. .	14.04	50.30	64.34	2.53	—25.96	15.69	0.9
15 ac. & above	24.85	134.80	159.65	24.88	274.70	4.27	0.0

With the exception of *kharif* cereals in which the smallest sized group of holding is deficit, other cereals show a surplus which increases with the increase in the size o holdings. The two smallest size groups of holdings show a deficit in grain. Similarly the requirements of fodder in respect of three smaller size groups cannot be met from production on the farm. The deficit, however, decreases as the size of holding increases The large surplus of milk in the case of smallest holding size group demonstrates the im portance of dairying as a subsidiary occupation for the small cultivators of the area.

3. *Cost of cultivation of principal rabi crops (Rs./acre)*

The cost of cultivation of wheat, gram and mixture of wheat + gram was worked out for different sizes of holdings. The data are summarised below :

TABLE XX

Cost of cultivation of rabi crops

Size of holding groups	Wheat	Wheat+ Gram	Gram
Less than 5 acres	318·57	249·10	136·65
5 to 10 acres	286·69	217·98	108·78
10 to 15 acres	286·40	204·82	106·36
15 acres & above	258·79	201·51	99.94

The per acre cost of cultivation for all the three principle *rabi* crops of the area decreases with an increase in the size of holding. This may be attributed to greater intensity of cultivation, quite often wasteful in the smaller size group.

IX. Agricultural Extension

1. *Role of extension education in the promotion of better village cooperatives*

Personal contact + literature have proved successful in case of managing body and ordinary members while discussion meetings+audio visual aids have been more helpful in improving cooperative attitude amongst non-members. It has been found that village leaders below 55 years age and with education if activated through personal approach and literature become potential workers.

2. *Agricultural Extension through Rural Youths*

Age group below 13 years gave the best response to acceptance of agricultural practices as compared to higher age groups. The increase in knowledge about practices was positively correlated with increase in education. Size of holding of the parent indicated no significant increase in the acceptance of practices.

3. *Agricultural extension through rural leadership*

Leadership in the village is diffused and centered around factions, caste, riches and traditional history, each leader influencing his own following. In the eight villages in which the investigation was conducted there was no single leader in any of these villages.

4. *Efficiency of village level workers as affected by different levels of academic standards and the influence of rural and urban background*

Village level workers with rural background and education up to intermediate standard gave better performance over village level workers possessing urban background and education up to matriculation or middle standard. Rural background showed significant superiority over urban background.

5. *Investigation into extension methods for introducing improved agricultural implements*

Amongst method demonstration, result demonstration and distribution of pamphlets, the combination of method demonstration and result demonstration proved significantly superior over other combinations or single extension methods. While amongst single methods result demonstration was found to be the best in persuading farmers to adopt improved implements like Olpad thresher, Sharma-hoe and furrow turning plough. Correlation studies with the acceptance of the practice and knowledge, skill and attitude showed that there is a positive correlation between acceptance of implements and change in knowledge, skill and attitude. Positive correlation with behaviour was found only in case of Sharma-hoe.

6. *Relative effectiveness of extension techniques for the success of soil and water conservation programme*

Out of the 5 teaching methods compared, the result demonstration proved superior over personal contact method demonstration, group meetings, discussions and distribution of literature in persuading the farmers to adopt water and soil conservation programme. While studying influence of socio-economic factors, the size of holding had a positive correlationship with acceptance of practice. The acceptance rate increased with the increase in the size of holding.

7. *Evaluation of extension methods for successful introduction of improved farm practices*

Teaching the farmers with combination of extension methods consisting of personal contact, method demonstration and flannelgraph proved best in the acceptance of improved variety of *bajra* T. 55, treatment of *jowar* seed with Agrosan G. N. and application of 20 lb. N for *bajra* crop. Socio-economic factors like age, education and size of holding did not show any significant effect on the acceptance of the practices excepting that age group 31 to 45 years was found to be more responsive than the higher or lower age groups.

8. *Effectiveness of certain extension techniques in relation to the socio-economic status of the farmers*

In this investigation the combination of personal contact, group discussion, meetings and distribution of leaflets proved to be the best method in teaching composting to the farmers as compared with the above methods used singly or in other combinations. Amongst socio-economic factors levels of education had a positive correlation with the acceptance of practice while age and size of holding did not show any such correlationship.

X. Programme of work for 1959-60

1. *Soil Fertility Section—*

(i) Building up of soil fertility through organic manures and inorganic fertilizers.
(ii) Building up of soil fertility through phosphate fertilization of legumes.
(iii) Building up of soil fertility through crop rotations combined with manures and fertilizers.
(iv) Experiments on mixed farming 6-acre holdings.

2. *Field Crop Section—*

(i) Response to manures and fertilizers.
(ii) Cultural experiments.
(iii) Varietal trials.
(iv) Agronomic experiments on grasses and legumes for pasture management.
(v) Grassland Scheme (I. C. A. R.).

3. *Vegetable and Commercial Crop section—*

(i) Response to manures and fertilizers.
(ii) Cultural experiments.
(iii) Varietal trials.
(iv) Vegetable growers' 3-acre holdings.

4. *Farm and Cattle Development Section—*

(i) Line breeding and selection for improvement in milk yield.
(ii) Feeding of stock on balanced ration for optimum growth.
(iii) Rearing of pail-fed calves on skim milk with urea.
(iv) Mixed Farming experiment.
(v) Intensive Cultivation Scheme and Key Village Scheme.

5. *Project under Second Five Year Plan*

(i) Irrigation Investigation Scheme.
(ii) Weed Control Investigation Scheme.
(iii) Agricultural Extension Scheme.
(iv) Plant tissue tests and foliar spray fertilization scheme.

6. *Agronomic Experiments at B.S.S. Pusa*

(i) Permanent manurial and rotation experiments.
(ii) New Manurial experiment.

7. *Agricultural Economics*

(i) Farm Planning and Budgeting.
(ii) Crop Planning and Mixed Farming.
(iii) Land Transformation.

XI. Agronomic Experiments at Pusa

Botanical Substantion, Pusa

A. 1 Permanent Manurial & Rotation Experiment, 1908-1909

Av. yield of grain in md. per acre

Plot No.	Treatment per acre	'A' Series			'B' Series		
		Maize	Peas	Barley	Maize	Barley	Wheat
1	No manure	3·63	1·83	..	2·91	11·31	..
2	F. Y. M. 4000 lbs.	10·29	7·43	..	12·17	9·91	..
3	F. Y. M. 8000 lbs.	11·51	14·92	..	16·29	21·12	..
4	F.Y.M. 4000 lb+rape cake 20 lb. N.	11·44	11·80	..	12·29	11·45	..
5	Rape cake 40 lb. N.	8·84	4·06	..	5·81	8·33	..
6	Am. sulph. 40 lb. N.	3·27	1·38	..	3·15	4·06	..
7	Pot. sulph. 50 lb. K_2O	3·63	2·38	..	3·88	7·19	..
8	Super 80 lb. P_2O_5	6·42	6·49	..	2·48	13·83	..
9	PK. as in plots 8 & 7.	7·27	6·59	..	4·54	12·89	..
10	NPK as in plots 6,8 & 7	8·78	7·14	..	5·03	19·29	..
11	NP as in plots 6 & 8	7·69	4·66	..	1·15	16·71	..
12	G.M. in cereal rotation	G.M.	..	7·09	G.M.	..	4·76
13	No manure	2·42	1·36	..	1·63	5·10	..
14	NK. as in plots 6 & 7	1·87	1·51	..	1·45	11·25	..
15	G. M. & legumes in the rotation	4·78	2·92	..	G.M.	14·87	..
16	As in plot 15,plus 80 lb.P_2O_5 to G.M.	9·81	6·64	..	G.M.	20·48	..
17	Cereal rotation	0·78	..	3·89	0·64	..	1·58
18	No manure	0·98	2·02	..	0·64	9·19	..

'A' Series—

Maize : Highest yields were obtained from the plot manured with F.Y.M. at 8000 lbs. plus allowed by treatments FYM plus rape cake, FYM 4000 lbs., G.M. plus super, rape cake plus NPK.

Peas : With this crop, highest yield was given by the FYM 8000 lbs., followed by FYM plus rape cake, FYM 4000 lb., NPK, G.M. plus super, PK and P treatments.

Barley : This was grown in two plots, *viz.*, 12 and 17. The yield of barley in the cereal rotation (No. 17) was very poor.

'B' Series—

Maize : Here also, highest yield was obtained from the treatment FYM 8000 lbs. followed by treatments FYM plus rape cake, FYM rape cake and NPK.

Barley : On this crop, the highest response was shown by FYM 8000 lbs., followed by GM plus super, NPK, NP and G.M. treatments.

Wheat : As in 'A' Series poor yields were recorded from the plot under purely cereal rotation.

Botanical Substation, Pusa—Contd.

A. 2 New Manurial Experiment, 1932-33

Av. yield of grain in mds. per acre.

Treatment per acre	Maize No.2	Wheat NP 52
A. No manure (Control)	5·02	4·00
B. F. Y. M. 8000 lbs.	11·61	10·71
C. Rape cake 40 lb. N.	10·74	6·59
D. Am. sulph. 40 lb. N.	6·59	5·54
E. Pot. sulphs. 80 lb. K_2O	5·53	4·69
F. Super 80 lb. P_2O_5.	5·76	5·18
G. PK as in treatments F&E	4·00	4·19
H. NPK as in treatments D, F, E. . . .	6·63	5·97
I. NP. as in treatments D & F . . .	7·21	6·25
J. NK as in treatments D & E	5·02	6·25
'F' test	Sig. 1%	Sig. 1%
S. Em.	0·96	0·53
C. D. 1% ± . . .	2·66	1·49

Maize : Significantly high yields were obtained from treatments FYM 8000 lb. and rape cake. Differences among the other treatments were not found to be significant.

Wheat : With this crop also, significantly highest yields were shown by the treatment FYM 8000 lb. and this was followed by rape cake, NP, NK and NPK treatments.

Agricultural Research Substation, Karnal

1. *General*

The area as cropped in *kharif* and *rabi* seasons were 186.52 and 248.93 acres respectively. The cropping intensity was 142.7 per cent for 1958-59.

The main activities of the substation were to conduct research on (i) the agronomy of various field and vegetable crops ; (ii) to multiply and distribute nucleus seeds of improved strains of field crops; and (iii) to render assistance to different Divisions of the Institute in carrying out programmes of (a) breeding for smut and bunt resistance in wheat, (b) research in pathology of red rod and wilt of sugarcane, (c) epidemiological investigation on cotton pests, and (d) Co-ordinated projects on fertilizers and soil fertility.

2. *Response of crops to season*

The monsoon set in by the 21st July, 1958 which delayed transplanting of paddy and sowings of other *kharif* crops. The total precipitation received during the year was 986.4 mm. The rain fall during the year was 657.2 mm. more than the normal. The distribution, however, was rather disuniform.

The condition of the crops was very satisfactory. There was no serious attack of any insect pests and periodical dustings and sprayings were given as a prophylactic measure. The incidence of yellow rusts on a few of the varieties was quite serious.

The yield of the principal crops grown on the farm during the year are given below :

1958-59

	Area acre	Yield /acre mds.
Grain Crops—		
Paddy	34·86	26·7
Wheat	146·23	15·6
Oats	6·10	19·8
Gram	16·09	17·0
Pea	6·27	11·5
Maize	19·92	10·3

1958-59

	Area acre	Yield/acre mds.
Fodder Crops—		
Jowar	18·22	202·0
Cowpea	4·00	245·8
Berseem	5·85	481·4
Oats	8·98	174·8
Cash Crops—		
Cotton	17·16	7·7
Sugarcane	2·00	692·5

Due to heavy rains the yield of cotton and maize crop suffered. The *rabi* sowings were completed on conserved soil moisture.

3. *Research Projects*

A. Manurial experiments

(a) *Sowing dates, spacings and levels of nitrogen experiment on paddy.*—This was the second year of the experiment. The treatments consisted of 5 spacings (6″×6″, 8″×8″, 10″×10″, 5″×20″ and 6″×18″) three levels of nitrogen (0, 30 and 60 lbs. N) and three dates of transplanting (D1—5th July and D2—20th July).

TABLE I

Interrelationship of nitrogen doses, dates of transplanting and spacings

Yield of Paddy in mds. per acre

Spacings.	Nitrogen levels lb./acre			Date of transplanting		Mean
	0	30	60	5th July	20th July	
S_1 6″×6″	24·2	33·1	32·2	26·0	33·7	29·8
S_2 8″×8″	31·7	40·0	40·1	35·9	38·6	37·3
S_3 10″×10″	30·1	42·3	42·0	38·3	38·0	38·2
S_4 5″×20″	23·3	39·8	40·1	32·1	36·7	34·4
S_5 6″×18″	23·4	34·5	37·3	30·3	33·1	31·7
Mean	26·5	37·9	38·4	32·5	36·0	..
S. Em.	..	±0·51	..	..	±0·41	±1·66
'F' test	..	Sig.	..	..	Sig.	Sig.
C. D. at 5%	..	1·45	..	..	1.17	5.41

The results showed that spacing of 10×10″ produced the highest yield (38.15mds./acre) and was at par with spacing of 8″×8″ (37.26mds./acre) and 5″×20″ (34.40 mds./acre) and significantly superior to spacing of 6″×6″(29.82 mds./acre) and 6″×18″(31.70″ mds./acre). The application of 60 lb. N dose to the soil produced 38.35 mds. and 30 lb. N, 37.93 mds./acre. Both the doses of nitrogen, thus, gave higher yield than no nitrogen treatment (26.5 mds./acre) significantly. Transplanting on 20th July (36.02 mds./acre) proved significantly superior to transplanting on 5th July (32.51 mds/acre). The combination of 20th July date of transplanting with 30 lb. N dose with 10″×10″ spacing proved to be the best treatment (Table I).

(b) *Spacings, No. of seedlings and levels of nitrogen experiment on paddy.*—This was the second year of the experiment. The treatments consisted of 5 spacings (6″×6″, 8″×8″, 10″×10″, 5″×20″, and 6″×18″) three levels of nitrogen (0, 30, 60 lbs. N/acre) and three seedling number per hill (2, 4 and 6).

TABLE II

Interrelationship of nitrogen doses, spacings and number of seedlings per hill

Yield in mds./acre

Spacings	Nitrogen levels lb/acre			No. of seedings per hill			Mean
	0	30	60	2	4	6	
S_1 6″×6″	23·5	30·2	38·4	27·4	31·5	33·2	30·7
S_2 8″×8″	23·6	32·6	40·2	29·3	33·9	33·4	32·2
S_3 10″×10″	23·9	29·3	39·0	29·6	30·5	32.0	30·7
S_4 5″×20″	19·9	26·7	34·7	24·4	27·5	29·3	27·0
S_5 6″×18″	19·4	28·5	35·8	26·0	28·9	28·8	27·9
Mean	22·1	29·4	37·6	27·3	30·5	31·3	29·7
S. Em	..	±0·72	..	..	±0·72	..	±2·21
'F' test	..	Sig.	..	..	Sig.	..	Not sig.
C.D. at 5%	..	2·71	..	..	2·71	..	..

The results given in Table II showed that 60 lb. N/acre produced 37.59 mds./acre and was superior to 30 lbs. N/acre which in turn was significantly superior to no nitrogen. Four and six seedlings per hill were at par between themselves and gave yields of 30.46 & 31.32 mds./acre respectively. These treatments were significantly superior to 2 seedlings per hill which gave the lowest yield of 27.32 mds./acre.

(c) *Phosphate fertilization of legumes and its indirect effect on paddy yield.*—The two legumes consisted of gram and pea. The three levels of phosphate in the experiment were 0, 15 and 30 lb. P_2O_5 per acre and unmanured fallow plots. Ammonium sulphate was applied to succeeding paddy crop at 0, 15 and 30 lb. N/acre level of nitrogen after the legumes in *kharif*.

TABLE III

Yield of paddy after legumes in relation to residual effect of phosphate and direct effec of nitrogen levels—Mds./acre

Levels of nitrogen per acre	Fallow	Legumes		Phosphate levels lb./acre			Mean yiel per acre
		Gram	Peas	0	15	30	
Nil		31·3	30·3	29·7	33·1	29·6	30·8
15 lb N . ..		37·0	35·6	35·8	37·9	35·2	36·3
30 lb N . ..		40·5	39·3	39·7	41·3	38·7	39·9
Mean .	31·4	36·3	35·1	35·1	37·4	34·5	35·7
S. Em. .	±1·01	..	..	..	±0·64	..	±0·64
'F' test .	Not Sig.	..	..	..	Not Sig.	..	Sig.
C.D. at 5% .	..	..	..	..	..	..	1·80

The results indicate that direct fertilization with nitrogen increased the yield of paddy by 6.0 and 9.5 mds./acre for 15 lb. N and 30 lb. N levels per acre respectively. The yields of paddy after gram and after pea were significantly greater than the paddy yield after unmanured fallow (31.38 mds./acre). Phosphate effects were not significant.

(d) *Differential response to nitrogen levels in relation to dates of sowing and spacings on maize.*—The results of second year's experiment and closer spacings 24″×9″ and 24″×12″ produced 16.64 and 16.85 mds./acre respectively and were at par between themselves. Both these spacings were significantly superior to the wider spacing of 30″×12″ which gave the yield of 14.76 mds./acre. Among dates of sowing first July sowing yielded 18.21 mds./acre which was the highest but this yield did not differ significantly from 15th June (16.79 mds./acre) sowing. Both these dates were significantly superior to 15th July (13.25 mds./acre) sowing. Application of 60 lb N/acre. (21.01 mds./acre) was found to be significantly superior to 30 lb. N/acre (17.52 mds./acre) which, in turn, was significantly superior to control treatment (9.72 mds./acre). Dressing of phosphate even as high as 60 lbs P_2O_5 /acre did not manifest its effect on the crops. The interaction of nitrogen levels and dates of sowings was found to be significant. At both the levels of N, last date of sowing (15th July) yielded consistently less than other two dates (15th June & 1st July) of sowings.

(e) *Fertilizer placement experiment on cotton.*—This is the second year of the experiment. Two sources of phosphate, superphosphate and ammonium phosphate, at two levels of 20 lbs. P_2O_5 and 40 lbs. P_2O_5 were applied by three methods of placement, namely (i) broadcast, & (ii) drilling 2.5″ below seed, and (iii) band placement to the soil for cotton 216F/14 along with a basal dressing of nitrogen as ammonium sulphate @ 30 lbs. nitrogen/acre.

Table IV

Relative response to doses of superphosphate & ammonium phosphate by various placements at two levels of P_2O_5 on cotton

Methods of placement	Levels of P_2O_5 lb./acre		Sources of Phosphate		Mean
			Super	Amm. phosphate	
	40	20			
Broadcast	10·1	8·6	9·2	9·4	9·3
Drilled 2½" below seed	10·1	8·7	9·3	9·5	9·4
Band broadcast	9·8	9·2	9·4	9·5	9·5
Mean	10·0	8·8	9·3	9·5	9·4
S. Em.	±0·29	..	.. ±0·29	..	±0·36
'F' test	Sig.	..	.. Not sig.	..	Not sig.
C. D. at 5%	0·85	..	..	..	..

The results showed that there was no significant difference between the yields of seed cotton due to ammonium phosphate (9.49 mds./acre) and superphosphate (9.29 mds./acre). The yields of seed cotton obtained by application of 40 lb. P_2O_5 was significantly superior to 20 lb. P_2O_5. But, there was no difference in the methods of placement of fertilizers.

B. Varietal trials

(f) *Trial of fine and medium fine types of paddy.*—13 varieties of paddy namely, N.P. 125, N.P. 130, N.P. 137, Palman, 34-22, Palman 246, Begmi 290, Begmi 292-19, Basmati 370, T-9, T-21, T-138, Sonpattar 4-12-19 and Sonpatter 7-2-5, were tested for their yield performance in this locality. The differences in yields of varieties were significant. Variety N.P. 130 produced the highest yield of 34 mds./acre. Variety T-21 was the next best yielder amongst the rest of the varieties.

(g) *Varietal trial of coarse and medium coarse types of paddy.*—The varieties included in this experiment were Jhona 349, Jhona kesarwala S-20, Jhona kesarwala 269, CH-10, 41, 42, 43, 54, 63, EK-70, Z-31, N.P. 97 and T-43. The differences in paddy yields of varieties were significant. Variety Z-31 produced the highest yield of 32.4 mds./acre and it was significantly superior to all the other varieties except EK-70 which produced 28.7 mds./acre. Variety N.P. 97 gave yield of 25.8 mds./acre. The Chinese varieties CH-43, CH-42 and CH-10 produced poor yields.

(h) *Observational trial with other paddy varieties.*—Besides the above varieties 24 varieties of paddy, namely ; CH 45, T-100, Kelaba, LH 5, N-10B, T-137, Kamod sital, B.K. 115, S.L.O. 9, T 136, T-3, Kamod Sal farm, CH-47, T-88, Salbika, Sona, CH-2, B.K.

141, Dundar 43, B-76-116, T-1, Salsutar, Zeera sal, and T-41 were under observation. The varietal differences in paddy yields were significant. Variety LH 5 gave the highest yield of 44.6 mds. per acre, other varieties which showed superior performance were, BK 142 (42.80 mds./acre), T-88 (40.50 mds./acre), T-100 (39.50 mds./acre), BK 115 (38.50 mds./acre), S.L.O. 9 (38.20 mds./acre), T-137 (36.40 mds./acre) and CH 45 (35.00 mds./acre).

C. Cultural Experiments

Response of wheat to tillage treatment together with manures and fertilizers.—In the third year of the experiment, the differences in yield due to cultivation treatments were not significant. The manurial treatments consisted of green manure, F.Y.M., ammonium sulphate and superphosphate in various combinations. The results showed that all the combinations were significantly superior to control. On the whole, green manure and ammonium sulphate proved to be superior to farm yard manure or 30 lb. P_2O_5 per acre treatment.

Paddy—wheat rotational experiment.—The four rotations compared for the third year are given in Table V.

TABLE V

Relative yield of paddy in various rotations

Rotation	Paddy
A. Paddy-Wheat-Cowpea-Wheat	15·4
B. Paddy-Berseem-Paddy-wheat	23·6
C. Paddy-Gram-Paddy-Wheat	26·3
D. Paddy-Wheat-Paddy-Wheat	17·2
S. Em.	±1·75
Sig. by 'F' test	Sig.
C. D. at 5%	5·28

40 lb. N/acre and 80 lb. P_2O_5 /acre were applied to cereals and legumes respectively to find out the effect of phosphate fertilization of *kharif* and *rabi* legumes in predominantly cereal rotation with nitrogen dressing to cereals, as judged by the yield of cereals. The data of the paddy crop are reported as under. The differences in paddy yields due to various rotations were significant. In the third rotation paddy yield was the highest of 26,33 mds./acre. In the completely cereal rotation the paddy yield averaged 17.2 mds./acre.

D. Cultivator's holdings

Four 6—acres holdings were laid out in 1955-56. To test two improved rotations (with nitrogen application for the cereals and phosphate application for the legume) in which

a) Paddy as the principal cereal and sugarcane as the cash crop and (b) wheat as the principal cereal and sugarcane as the cash crop, against the third holding in which cultivator's rotation and manuring schedule common to this locality was adopted. In this holding, wheat as principal cereal, sugarcane and cotton as cash crops were included in the rotation without application of nitrogen or phosphate fertilizers to the cereals or legumes. The cropping of the fourth holding consisted of paddy as the main cereal crop and sugarcane as cash crop with nitrogen and phosphate fertilizer applied to the soil for cereal and legume production respectively was also laid out, but with lesser intensity of cropping.

The first cycle of rotations was completed this year. Seven years' study have given the following results :

(a) *Building up of soil fertility.*—The yields in the three holdings with recommended improved rotations, cultural and manurial practices are definitely higher than the holding with local rotation, cultural and manurial practices. The effect of phosphate manuring of legume and direct application of nitrogen to cereals in buildings up of soil fertility is clear from the yields of different holdings. These are given in Table VI.

TABLE VI

Gross and average yield of crops in holdings—mds./acre

1955-56 to 1958-59

Commodities	Intensity of cropping/yield of crop—mds./acre							
	Holding I (192%)		Holding II (175%)		Holding III (175%)		Holding IV (158%)	
	Gross	Per acre	Gross	Per acre	Gross	Per acre	Gross	Per acre
Cereals . . .	288·8	24·1	245·0	17·2	194·5	13·4	340·0	24·3
Pulses . . .	135·0	11·3	116·1	14·6	71·7	12·0	51·0	12·6
Green fodder . .	5459·6	474·7	4136·1	318·2	1412·1	285·4	3348·8	352·3
Dry fodder . .	404·8	17·6	480·0	26·7	347·3	17·4	401·7	22·8

The yields in holding Nos. 1, 2 & 4 were generally higher than in holding No. 3 which conforms to the local practices. The effect of phosphate fertilization of berseem and application of nitrogen to cereals is evident from the higher yields in holding No. 2 than in holding No. 3. Yield of cereals is slightly higher in holding No. 4 which contains paddy than in holding No. 2 in which wheat is the principal cereal crop.

(b) *Whether the production was sufficient to meet the requirement of* 5 *adults male member and seven cattle.*—The normal requirements of an adult have been calculated on the basis of 3,000 calories of food in the form of cereals, pulses and milk etc. The basis of calculation of ration per milk animal is the maintenance and milk yield at 5 seers per day per cow and 7 seers per day per buffalo. The number of working days has been taken

at 200 days per annum. The data of requirements and production indicates that maximu surplus of Rs. 2172.47 was obtained in holding No. 1. Holding No. 2 also showed som surplus of Rs. 130.00, while other two holdings, namely ; holding No. 3 with local pra tics and holding No. 4 with lesser intensity of cropping exhibited a deficit of Rs. 2755.9 and Rs. 396.11 respectively.

Work of other Divisions

Botany Division :

(i) Wheat varietal trials under *barani* and irrigated conditions.

(ii) Wheat Bunt Control Experiment.

Mycology Division :

(i) Study of diseases in different varieties of sugarcane.

Entomology Division :

(i) Biological control experiments on cotton insects.

(ii) Biological control experiment on maize stem borer.

(iii) Control schedule of cotton pests.

Seed supply.—The quantities of seeds of improved varieties of crop distributio during the year were wheat—1804 mds. ; maize—142.9 mds. ; gram—117.5 mds. ; paddy— 54.4 mds. ; pea—51.1 mds. ; oats—34.3 mds. and miscellaneous 7.2 mds. These were nucle ous stocks which were distributed for further multiplication.

Research Programme for 1959-60

1. Conduct manurial trials with paddy, wheat, maize, cotton legume and vegetables
2. Tillage experiments with wheat.
3. Rotation experiments with paddy.
4. Cultural experiments with cereals and cash crops.
5. Varietal trials with wheat, paddy and linseed.
6. Cultivator's mixed farming holdings.
7. Large scale field experiments of the various Divisions at the Institute.

Annual Report of the Statistice Section for the year ending 30th June, 1959

A. Advisory and Training

A large number of lay-out plans for field and laboratory experiments were prepare and voluminous data on the various research projects sponsored by the various Division of the Institute were statistically analysed and their results were reported to them. Further training in Experimental Statistics was conducted for the students of (i) P. G. School (ii) Central College of Agriculture, (iii) Soil Conservation, Research and Demonstratio Centres, Ministry of Food and Agriculture, and (iv) State Assistant Soil Chemists of Soi

Testing Service Scheme. Advice was also given to the research staff and the P. G. Students of the Institute in designing of new experiments and also in the Statistical analysis and interpretation of the data on their research problems.

B. Research Projects

1. *Genetical aspect of milk improvement in Sahiwal herd*

In continuation with the study of dairy records of the Sahiwal herd maintained by the Institute for Scientific breeding purposes, made in the previous year, the data were further examined for (i) Heritability of milk yield, (ii) Standardization of records, and (iii) optimum age at 1st calving. The summary results have been stated under each head separately.

(i) *Heritability.*—Heritability of milk yield as worked out by intra sire regression method after eliminating the variation due to age, times of milking and lactation period was found to be above 70 per cent for the herd and was highly significant. Presently, Cello line has been continuing and the heritability for this line has been found to be approximately 62 per cent which was also significant at 5 per cent level.

(ii) *Standardising the records.*—A study of the relationship between age and milk yield was carried out both when the age was measured in lactations and also when it was measured in months. Quadratic curves were fitted separately for these two cases. From these equations the age of a cow was determined at the maximum yield. The age was found to be 6.33 lactations in the first case and 120 months or 10 years in the latter case respectively. Further, factors for correcting the yields in different lactations were worked out.

(iii) *Optimum age at 1st calving.*—Early maturity experiments were started at the Institute in 1932 to increase the productive life of the animals in the herd. Age of the cows at 1st calving was correlated with the first lactation yields to study the effectiveness of these experiments. The coefficient of correlation was not found to be significant indicating that reduction in age at first calving did not affect the yield adversely. Subsequently, age at first calving was grouped into three monthly class intervals and the average yield per lactation throughout the life time of an animal was worked out corresponding to each interval to examine the nature of the relationship.

2. *Sampling Methods for growth characters and yield of crops*

Sampling for maize yields.—An experiment on sampling of maize to determine an appropriate sampling unit for estimating the grain yield of an experimental plot was carried out during *Kharif* 1958. 10 and 20 per cent sample areas were harvested from 24 plots of the crop of maize grown for "Irrigation seminar" in Top Block-I. The data regarding total produce and yield of grain were then collected separately for each sampling unit from all the plots, and analysed statistically for the grain yield and the ratio of grain to the total produce, as was done in the previous seasons.

The percentage errors obtained in the ratio estimates with different intensities of sampling were appreciably lower than the corresponding errors in case of the grain yield of samples. With ratio estimates, as the number of samples drawn was increased from one sample to four samples, the percentage error changed from 4.3 to 2.1 and 4.5 to 3.2

for 20 and 10 per cent sampling units respectively. In the case of grain yield, there wa about 4 per cent reduction noticed in the error for both kinds of sampling, as the intensit of sampling was raised from one to four. However, the individual percentage errors i the latter case were very high. Further it was also observed that 20 per cent samplin indicated consistently lower errors than 10 per cent sampling.

Out of the two methods of estimation, the ratio estimate was found to be mor reliable. Although under the ratio estimates, 20 per cent sampling indicated lower error than 10 per cent sampling, but the difference was small to prefer the 20 per cent samplin unit over the 10 per cent sampling unit. A 10 per cent sampling unit taken twice wa considered to be the best as in the previous two years.

3. *Analysis of water level records* (1940-54)

The data on water level of 13 wells situated in the Institute fields were again taker up for statistical analysis with a view to find out the theoretical trends of water levels dur ing the months of May and June *i.e.* before monsoon and in October and November *i.e* after monsoon for the period of 15 years. Graphs were also prepared to indicate yearly and monthly variations in the water level of the wells. Further work is in progress.

4. *Crop cutting Experiments in the villages under the I.A.R.I. Intensive Cultivation Scheme*

The crop cutting experiments in the villages of the I.A.R.I. Intensive Cultivation Scheme were conducted in *rabi* 1958 with the following two objectives :—

(i) To determine the response of wheat to the application of N.P. fertilizers under village conditions.

(ii) To compare the relative performance of N.P. 824 and N.P. 718 varieties as adopted by the cultivators.

For the first study seven villages out of the 19 villages of the scheme were selected at random. From each village 2 sets of demonstration plots were further chosen randomly. On the basis of 2 pairs of cuts from each village, in all 14 pairs of plots each of 1/80th of an acre, were harvested but threshing in respect of only 12 pairs was done as the pro duce from the remaining two cuts got mixed up. The data were then statistically analysed.

The response to NP (Ammonium sulphate 20 lb. N per acre × superphos. 20 lb. $P_2 O_5$ per acre) varied from village to village and on the average a significant response of about 3 maunds per acre was obtained.

For the second item, very few comparisons were available since the variety NP 824 was newly introduced. As such no proper study could be made.

5. *Manurial Experiments conducted in the Division of Agronomy from* 1936-37 *to* 1956-57

The voluminous data on the manurial experiments conducted in the Division of Agronomy since 1936-37 on various crops were examined statistically with a view to study the suitability of the fertilizers and also to determine an optimum economic dose of various fertilizers in relation to different crops. The study on (i) wheat, (ii) Maize, (iii) Berseem,

iv) Sugarcane, (v) Oilseed crops, (vi) Potatoes, (vii) Peas, (viii) Cotton, and (ix) Tobacco was completed, and summary reports were also prepared and sent to the Director and to the various Heads of Divisions. Further on the basis of these reports, "A Bulletin on Fertilization of crops" is being prepared. In this connection, the chapters on (i) Introduction, (ii) Review, (iii) Section on wheat, and (iv) Section on Maize have been drawn up.

The various findings on the crops so far dealt with are summarised below.

Wheat.—(i) All the types of nitrogenous fertilisers have been found to be useful for wheat crop and that fertilizers in general were superior to manures.

(ii) Ammonium sulphate has been more profitable than other form of nitrogenous fertilizers. The optimum dose of this source material worked out to be 40 lb. N per acre.

Maize.—(i) Fertilizers were more profitable than manures for this crop as well.

(ii) A dose of 60 to 70 lb. N per acre of ammonium sulphate was required to obtain an extra profit between Rs. 30 to 75 per acre with the prices of maize grain at Rs. 8 to 12 per md.

Sugarcane.—(i) Application of fertilizer in the form of ammonium sulphate was profitable up to a dose of 120 lbs. N per acre, but the economic optimum dose worked out to be 80 lb. N per acre.

(ii) Calcium Nitrate was a better form of nitrogen than Chilean Nitrate or Ammonium sulphate, but it was not found to be beneficial beyond a dose of 40 lb. N per acre.

Linseed.—(i) Linseed responded well to the various types of nitrogenous fertilizers. Ammonium Sulphate Nitrate was the most profitable form of nitrogen followed by ammonium sulphate and Nangal (Calcium ammonium nitrate) fertilizer.

(ii) 60 lb. N per acre was the optimum economic dose of each type of nitrogenous fertilizers listed above.

Sesamum.—(i) Application of ammonium sulphate, farm yard manure or groundnut cake up to a dose of 60 lb. N per acre was not profitable.

(ii) Micronutrients did not indicate any material advantage over the nitrogenous fertilizers.

Berseem.—(i) Response of barseem to superphosphate in general was good. Low doses of superphosphate were more effective as compared to high doses.

(ii) A dose of 60 lb. P_2O_5 per acre of Superphosphate was the economic optimum one.

(iii) Superphosphate and next ammonium phosphate were the only forms of phosphates useful among the various other forms of phosphates. A dose of 130 lb. P_2O_5 per acre of these two forms was necessary to obtain maximum profit.

(iv) Farm yard manure was found to be equally effective like superphosphate.

Peas.—(i) Superphosphate responded well with peas. A dose of 120 lb. P_2O_5 per acre was the optimum economic dose under irrigated conditions, but under rainfed condition, a dose of 60 lb. P_2O_5 per acre was economical.

(ii) Superphosphate and potassium sulphate combination was economical but th addition of nitrogen to this combination was not beneficial.

(iii) Low doses of ammonium sulphate under rainfed conditions indicated profit

Potatoes.—(i) Ammonium sulphate was beneficial to the crop of potato. The econo mic optimum dose was 120 lb. N per acre.

(ii) Superphosphate and potash when mixed with ammonium sulphate indicate higher yields but the mixture was uneconomical. Superphosphate alone did not sho significant response in tuber yields as well.

Cotton.—(i) Application of nitrogenous fertilizers was profitable. Chilean nitrat was more beneficial than ammonium nitrate and ammonium sulphate. The optimun economic dose of chilean nitrate was 30 lb. N per acre and that of ammonium nitrat and ammonium sulphate was between 30 to 40 lb. N per acre.

(ii) Superphosphate combined with nitrogenous fertilisers did not manifest its effect

Tobacco.—(i) Ammonium sulphate was useful for tobacco. The economic optimun dose was 40 lb. N per acre.

(ii) Superphosphate showed very little benefit for this crop, but potassium sulphat did not show any response.

C. Statistical Analysis of data from different Divisions

During the year under report, very lengthy data on the experimental projects of the various Divisions of the Institute were statistically analysed and reports were prepared and sent to the respective Divisions. Some of the important projects are listed below Division-wise :

Agronomy.—(i) Optimum time of application of nitrogenous fertilizers to wheat (1957-58).

(ii) Paddy varietal trial (1958).

(iii) Model Agronomic Experiments at Karnal (1958).

(iv) Cultural experiment on cotton (1952-57).

(v) Comparison of response to Ammonium sulphate and F.Y.M. alone and in combination—(wheat, 1958-59).

Entomology.—(i) The effect of carriers on the toxicity of B.H.C. and D.D.T. (1958).

(ii) Biological control experiment on maize at Karnal (1957).

(iii) Viability percentage of Tetrastichus pyrillae craw.

(iv) Control Schedule for pests of maize (1958).

(v) Population data of various insects and pests occuring on cotton.

Chemistry.—(i) Data on "Rapid Soil test Scheme" from three centres.

(ii) Phospho Bacterin experiment (Kh 1958) with Maize.

REPORT OF THE DIVISION OF BOTANY

(*Dr. A. B. Joshi*)

The research activity in the Division, continued under its four main sections, namely, Plant Breeding and Genetics, Cytology and Cytogenetics, Crop Physiology, Plant Introduction and Exploration. The primary objective of these investigations was, as in the past, the breeding of improved varieties of different crop plants, including cereals, pulses, oil-bearing plants, cotton, forage crops, and some vegetable and ornamental plants. The work on the improvement of maize and millets continued with the active cooperation of the Rockefeller Foundation. Fundamental and applied research work under the projects financed under the Second Five Year Plan, as also that under the various schemes financed by the Indian Council of Agricultural Research and the Commodity Committees progressed well. The 200-curie source of radio-active cobalt-60 was received from Canada during the year under report and considerable progress was made on the completion of the 3-acre Gamma Garden and on the fabrication of the remote-control actuating mechanism, for raising and lowering the cobalt source, with the help of the Atomic Energy Department, Bombay. The Gamma Garden is expected to be in operation very shortly, and this will mark the beginning of a useful programme of mutation research at the Institute as well as in the country at large. Another notable feature was the re-organisation of post-graduate teaching in the Division, under the Post-graduate School, leading to the M.Sc. and Ph. D. degrees of this Institute. At the request of the I.C.A.R., a short-term refresher course on Cytology, Genetics and Plant Breeding was held from June 1 to June 20, 1959, for the benefit of teachers in agricultural botany in the various agricultural colleges in India. A training programme on research and production techniques relating to hybrid maize was also put under way from July 1 to December 31, 1958, for trainees deputed by the State Departments of Agriculture.

A large volume of advisory and collaborative work, involving the exchange of scientific information and seed material, was done as in the previous years. The latter included the project of the F.A.O. for testing genetic stocks of wheat and barley against major diseases such as the rusts and bunts. Distribution of pure seeds of improved varieties of different crops, including vegetables, continued as in previous years.

A brief account of the results of the main lines of work is given below.

Plant Breeding and Genetics

1. *Improvement of Indian wheats*

The work on breeding agronomically superior wheats, combining resistance to rusts, smut and other diseases, is being carried out at Delhi and at five other centres : Simla, Bhowali, Pust (Bihar), Indore and Wellington (Nilgiri Hills). The programme at Indore and Wellington is directed mainly to the breeding of rust resistant *durum* and *dicoccum* wheat respectively; whereas at the other centres the emphasis is on the breeding of disease resistant bread wheat (*Triticum aestivum,* syn. *T. vulgare*) for the hills and plains of India. Studies on the fundamental aspects included those on the genetics of disease resistance and other characters.

(i) *Assessment of foreign wheat varieties.*—As a result of further arrivals through the F.A.O. and other sources, the number of accessions of foreign wheat varieties stood at 4533. Six of the newly received exotics of *Triticum aestivum, viz.,* Bonza from Mexico ;

St. 464 from Ethopia ; and Frontana × Kenya=58—New Thatch II-50-32, Frontona × Keny -58—New Thatch II-50-34, (Maria Exobar × Mc Murachy Minn 2698) × Maria Exobar II 61-42 I.R.I.—65, and (Mida—New Thatch × Kenya 117 A) II-45-24 from the U. S. A showed combined field resistance to all the three rusts. Some of the newly-received foreig varieties of *T. durum*, such as E 4461 from Portugal, E 4462 and E 4464 from the U.S.A and E 4466 from S. Africa, appeared to possess field resistance to yellow rust.

(ii) *Improvement of* aestivum *wheats*—(a) *Rust resistance.*—Several selections, re sistant to black, brown and/or yellow rust and possessing good productivity and grai quality, were isolated from several crosses involving indigenous *aestivum* wheat varietie and disease resistant foreign wheats. Some of the selections have been observed to b free, in the field, from all the three rusts, whereas other selections have shown high resis tance to individual rusts or to two rusts. In these studies, N.P. 718, N.P. 760, N.P. 790 an Rio Negre have appeared to be excellent combiners. The most notable among these selec tions are HD (52)-27, HP(53)-18, and HP(53)-31.

At Simla, crosses between the two improved hill wheats, N.P. 770 and Ridley, a also between these two wheats on the one hand and a number of rust resistant exotic on the other have yielded many cultures which possess high resistance to yellow rust to gether with greater productivity, strong straw, suitable maturity and good grain quality Twenty-three of the newly evolved rust resistant strains outyielded the controls.

Several of the selections made at Delhi and Simla were tested at Bhowali. From these tests, high yielding strains possessing good grain quality and resistance to yellow an brown rust have been located.

(b) *Loose smut resistance.*—In the programme of sorting out varieties resistant t loose-smut carried out at Delhi, sixteen types including the N.P. wheats 790, 797, 798, 799 822, 823, 824, 825 and 826, and some hybrid cultures showed complete freedom from th disease for the third year in succession.

(c) *Breeding varieties suited to different levels of soil fertility and moisture, an to different dates of sowing.*—Trials have been conducted at Delhi, and at Pusa for the past four seasons with fifty-one varieties comprising the newly evolved N.P. wheats and hybrid strains in advanced generations, with a view to determining their response t different sowing dates and manurial doses. N.P. 823 has been adiudged to be suitable for cul tivation under unmanured timely-sown or late-sown, conditions and manured late-sown conditions whereas N.P. 824 has been found to be suitable for being grown under manured timely-sown conditions.

Similar trials carried out at Karnal in Punjab showed that the hybrid strain, HD (52)-27, possessing good quality grains and a high degree of resistance to yellow rust and lodging, gives superior performance under high fertilization condition of the soil. This strain could, therefore, be considered suitable for being cultivated in Punjab.

Two-hundred-twenty-one rust resistant hybrid cultures were tested for performance under *barani* conditions at Delhi. Thirty-five of them performed better than the checks, giving greater yields.

In the Paonta valley of Himachal Pradesh and generally in the lower hills of Hima chal Pradesh and Uttar Pradesh, N.P. 792 has given encouraging performances. It appears to be a very suitable variety for growing after a paddy crop.

(d) *Yield trials of promising varieties and strains.*—Some of the rust-resistant wheats bred at the Institute were tried out against the local checks at 90 centres in the northern hills and 73 centres in the plains of the various States including Punjab, Bihar, Bengal, Orissa, Madhya Pradesh, Bombay and Mysore.

In the northern hills N.P. 824 and N.P. 829 gave very good performances at lower altitudes. In the plains also, N.P. 824 seems to exhibit a wide range of adaptability since it has given encouraging performance at a number of centres in the States of Bihar, Orissa, Bombay and Mysore, and also at Delhi and Karnal (Punjab). N.P. 825 gave significantly superior yields than the control types at Delhi and Jullundur (Punjab). N.P. 827 and N.P. 828 were severely affected by *Alternaria* in Bengal and Orissa. The hybrid culture, HP(53)-18 at Pusa in Bihar however showed moderate resistance to the disease and significantly outyielded N.P. 824.

(iii) *Improvement of* durum *wheats.*—Several selections from intervarietal hybrids of the black rust resistant type, Gaza, with indigenous *durums* were tested against a mixture of the races of black rust in the field at Indore. Sixty-three progenies were found to be free from black rust besides possessing other desirable agronomic features including good quality grains. Some of the strains are now in the final stages of testing.

(iv) *Improvement of* dicoccum *wheats.*—The recently-released *dicoccum* variety, N.P. 200 again showed its superiority over the local *Samba* wheat in yield trials conducted at various places in the Nilgiri and Palni Hills. Multiplication of nucleus seed stock of N.P. 200 was in progress at Wellington. Latest selections made at Wellington from the intervarietal hybrid, I.C. 1131 × Local Samba, have appeared even more promising than N.P. 200 as they combine brown rust resistance with semi-free threshing habit.

(v) *Milling, baking and* Chapati *making qualities of Indian wheats.*—Effect of storing flour for a period of time on the gluten content and quality was studied in the case of 20 wheats *viz.,* N.P. Nos. 710, 718, 758, 761, 770, 775, 792, 797, 798, 799, 809, 822, 823, 824, 825, 826, 827, 828, 829 and HD (52)-27. In these varieties gluten content of fresh flour ranged from 8 to 11% of the oven dry samples. The highest gluten content was shown by N.P. 710 and N.P. 718. The recovery of gluten fell considerably after 4 to 8 weeks of flour storage at 30°C. in the case of N. P. 775, N. P. 792, N. P. 827 and N.P. 828, whereas it remained more or less constant in the other wheats even up to the ninth to twelfth week of storage. In the flour samples the quality of gluten extensibility showed deterioration with age in storing ; the decrease in gluten extensibility was most rapid during the first 4-5 weeks of flour storage but from the 8th to 12th week no appreciable decline in gluten quality could be detected.

The effect of fertilizer doses and irrigations on the quality of wheat flour was studied in the varieties, N.P. 718, N.P. 823 and N.P. 824. Application of nitrogen at all levels (20, 40 and 80 lbs. per acre) led to an increase, whereas irrigations, in general, tended to result in decrease, of gluten and protein content of the grains.

(vi) *Genetics of rust resistance.*—The inheritance of resistance to individual races of black rust in the seedling stage, and of adult plant resistance to a mixture of races of black, brown and yellow rusts under conditions of artificial inoculation in the field, was studied in a number of intervarietal hybrids. Resistance to a particular race was found to be controlled by one, two or three duplicate genes in the different crosses. The exotic variety, Kenya—Gular—Pilot × K-58—New Thatch (E. 1913), was found to possess three dominant duplicate genes for resistance to the races 24 and 117 of black rust. Timstein derivative

(E. 871) and N.P. 718 are both susceptible to the biotype 15 C of black rust or its colou mutant; in the F of the cross of these two varieties a segregation ratio of 13 susceptible 3 resistant was recorded, indicating the operation of a dominant inhibitor. In the cross N.P. 790×C. 281, the resistance to the race 42 of black rust appeared to be conditione by two dominant complementary factors.

In the crosses of N.P. 790 with C. 273 and C. 518, the mature plant resistance o N.P. 790 C. 281, the resistance to the race 42 of black rust appeared to be conditione teraction of one dominant and two recessive factors. Similarly, the adult plant resistanc of N.P. 785 to a mixture of yellow rust races, appeared to be governed by four pairs of gene showing various types of interaction. As regards adult plant resistance of E. 871 to a mix ture of races of brown rust, resistance seemed to be controlled by two recessive complement ary genes in the crosses of E. 871 with N.P. 165, N.P. 718 and Pb. C. 281.

2. *Improvement of barley*

The work on the improvement of barley was continued at Delhi, Pusa, Simla Bhowali and Wellington. At Delhi, seven exotic types, *viz.*, the E.B. types 364, 389, 453 454, 458, 460 and 462, were free from black rust in the field. At Simla, some of the selec tions derived from the crosses of N.P. 100 with B. 122, B. 150 and B. 183 have shown con siderable field resistance to yellow rust; in addition, they were found to be agronomically useful. The strain, H. 21-6-4-208-13, evolved at Wellington from the cross, (B. 237 × B 150) × Local outyielded the local control significantly ; it is resistant to yellow rust under field conditions and has appeared to be very promising for cultivation in the Nilgiri and Palney hills area.

3. *Hybrid maize*

During the year, 1800 inbred lines including those received from the U.S.A. and South America were sown for maintenance and for further selection and inbreeding. These lines were also sown in a top cross block for testing their general combining ability ; the top-performing single cross, Kys × C.I. 21E, was used as a tester parent.

Three hundred and eight top crosses were tested in seven trials at different locations in maize growing areas of India. The number of top crosses that significantly outyielded the local check varieties were : 8 at Hyderabad, 55 at Srinagar, 125 at Tarai, 15 at Ajmer and 23 at Pusa. These top crosses gave an increased yield of, from 23 per cent to 107 per cent more than the check variety. Some of Retop performing lines were : G733W-75 K.T 41-267, Per 330-44 and Texas 325.

Twenty-seven maize hybrids from the U.S.A. were tested at 9 locations. The results are so far available from 8 locations. At Hyderabad the top-performing hybrid was Texas 28 which yielded 32 per cent more than the check variety ; at Srinagar, U.S. 523W outyielded the local variety by 78 per cent ; at Tarai, Almora and Arbhavi, Dixie 82 gave 70 per cent., 20 per cent. and 105 per cent. more yield respectively ; at Pusa Texas 30 gave 81 per cent. more yield, while at Ajmer and Kangra none of the hybrids was superior to local check. At the Indian Agricultural Research Institute, the trial was destroyed by the stem borer (*Chilo zonellus*). The damage due to infestation of the borer ranged from 75 to 95 per cent. in the different cultures.

4. *Improvement of millets*

(i) *Jowar.*—Breeding for improved grain and fodder varieties of jowar was in progress at Delhi. Selections 20-S and 20-S_4 from the cross, E.C. 4315 (Saeve Qrome *ex* Algeria) × I.C. 1517 (Early Prodigy) have appeared to be very promising, as compared to Early Prodigy, in grain yield. Promising selections have also been obtained from the cross, Sweet Sudan Grass (*Sorghum sudanense*) × T 263 (*Sorghum vulgare*) ; they combine the tillering habit of Sudan grass with good height and plant growth of T. 263. In a trial conducted at Mohol in Bombay State, with 14 different F_1 hybrid combinations obtained by using the cytoplasmic male sterile lines, Texas Black Hull and I.C. 2360 as mother parents, the hybrid—I.C. 2360 × I.C. 3664, gave about 69 per cent. more fodder yield than that of the superior parent.

(ii) *Bajra.*—Two exotic types introduced from Ghana, E.C. 11793 and E.C. 11794 significantly outyielded T. 55 in a varietal trial conducted at Delhi. Seven types obtained from South Rhodesia (E.C. 12681 to 12687) appeared to escape bird damage to a considerable extent owing presumably to the long bristles borne on their spikes.

5. *Cotton*

The existing collection of *Gossypium hirsutum* cotton was further augmented by the addition of 117 exotic cultures received mostly from the U.S.A. and the U.S.S.R. All but Strine from the U.S.S.R. proved to be susceptible to jassids. Strine showed remarkable resistance to jassids as compared to the local variety H. 14, but it is late flowering and susceptible to the blackarm disease. Promising breeding stocks from among the earlier collections include Sealand 7 received from the U.S.A. possessing 39.00 mm. halo length and K 3418 *ex* U.S.S.R. having good halo length (29.7 mm.) as well as high ginning value (39.6%).

6. *Linseed*

The high yielding, rust susceptible linseed varieties, N.P. 12 and N.P. 124, were subjected last year to irradiation with X-rays. In the X_2 generation of N.P. 12, comprising 5734 individuals, one plant stood practically free from rust under artificial conditions of rust inoculation in the field. In a varietal trial with 10 newly-evolved, rust resistant selections S. 208 was the best yielder, giving a calculated yield of 1743 lb. per acre as compared to 1500 lb. given by N.P. (R.R.) 9.

7. *Pigeon pea*

A replicated yield trial was laid out in a non-wilt sick plot in a randomized blocks design with 8 new selections and 4 check varieties. Due to unfavourable season, the sowings were delayed. Later, severe frost occurred during December-January. The yield differences among the varieties were not significant statistically; S. 79, S. 33, S. 68 and S. 37 gave yields statistically at par with the controls—N.P. 24, N.P. (W.R.) 15 and U.P. Type 105. In critical tests conducted in the Mycology Division, S. 37 showed 100 per cent. wilt resistance in both pot and field experiments ; U.P. type 105 and N.P. 24 showed, respectively 100.0 and 93.3 per cent. wilt mortality under pot tests.

8. *Spices and condiments*

(i) *Improvement of essential-oil-bearing plants.*—Work on the improvement of some essential-oil-yielding plants such as, *ajwain* (*Carum copticum*), *dhania* (*Coriandrum sativum*), *jeera* (*Cuminum cyminum*), *saumf* (*Foeniculum vulgare*) and *sowa* (*Anethum sowa*), was continued at Delhi and at the substations at Pusa, Jamnagar and Katrain. Botanically-distinct types have been isolated in these crops. The high yielding selections evolved during the previous years were grown in regional trials at a number of locations in Bombay State. The selections, N.P.J. Nos. 12, 66, 181 and 192 of *ajwain,* N.P.J. Nos. 214 and 230 of *dhania,* N.P.J. Nos. 205 and 269 of *saumf,* and N.P.J. Nos. 68 and 115 of *sowa* out-yielded the local checks in a number of trials. In *jeera,* Selection 149 gave 10% more yield than the improved type, Anand 404, of Bombay State.

The following selections recorded high essential oil content; the results will be confirmed next year.

Crops	Type	Essential oil content (per cent)
Ajwain	..	3·0–4·0*
	S·3	9·28
	S·8	7·28
	S·17	7·28
Dhania	..	0·1–0·25*
	S·12	0·56
	S·8	0·62
Saumf	..	1·0–4·0*
	E.C. 8458:S.P.1	7·28
Sowa	..	2·0–3·0*
	E.C. 11639	4·28

* Range for market samples.

(ii) *Chilli.*—The F_2 generation of the cross, N.P. 46A × Puri Red (mosaic resistant), as also the backcross progeny—(N.P. 46A × Puri Red) × Puri Red, were being tested for reaction to the mosaic virus in the Division of Mycology. The results are awaited.

Correlations between fresh yield of chillies and the various characters contributing to it were worked out. The characters having major influence on the fresh yield were: the number of fruits per plant, percentage of water content in fruits, and seed weight per fruit.

9. *Vegetables*

(i) *Tomato.*—18 F_1 hybrid combinations were tested for yield in a replicated yield trial in the field; the increased yields given by the F_1 hybrids over the parental means ranged from 28·3% to 104·5%. The first four high yielding hybrids were: Sanmarzano (ms = male sterile) × Sioux; Meeruti (ms) × Meteor; Meeruti (ms) × Pusa Ruby and Rutgers × Red Top giving estimated acre yields of 62726 lb., 52794 lb., 47916 lb. and 45825 lb. respectively as compared with the corresponding values for Sammarzano: 25264 lb., Sioux: 36067 lb., Meeruti: 28749 lb., Meteor: 30492 lb., Pusa Ruby: 30666 lb., Rutgers: 29310 lb. and for Red Top: 23522 lb.

(ii) *Peas.*—Yield trials with early and main season peas and with sugar-podded varieties were carried out. Among the early varieties, Yates Early crop (E.C. 4802) gave the highest yield. In the main season class, Bonneville topped the list. Among the sugar podded varieties, Sylvia (from Sweden) gave the best yield, as compared with Selection Reugenboter and Dwarf Sugar-podded.

(iii) *Bhindi.*—The recently evolved mosaic resistant selections of *bhindi* showed almost complete freedom from the yellow-vein mosaic disease in the field, whereas Pusa Makhmali and all the other varieties in the collection turned completely yellow owing to the disease. These selections have also significantly out-yielded Pusa Makhmali, the type under distribution.

(iv) *Carrot.*—F_2, F_3, and the first back cross generations of the cross between the Asiatic and the "temperate" forms of carrot, were studied in respect of the size, shape and quality of roots. In the Asian type, about 93.8 per cent. of the plants had branched roots of poor quality, whereas in the segregating progenies only 9.3 per cent. of the population showed branched roots. The selected roots from the F_3 progenies were planted for seed. Eighty per cent. of these flowered and set good seed under Delhi conditions, whereas the "temperate" carrot is not able to produce seed in the plains.

(v) *Turnip.*—In the F_3 generation of the cross of the Asian type of turnip with the temperate type, selections for desirable root characters were made. All the selected roots on replanting, produced seed satisfactority under the Delhi conditions, whereas temperate turnip is unable to do so.

(vi) *Spinach.*—In the F_2 progeny of Spinach beet × Swiss Chard, promising segregates showing fine leaves, late flowering and satisfactory seed formation at Delhi, were isolated. Some of the selections are likely to yield one or two more cuttings during the season.

(vii) *Sweet-potato.*—A red-skinned but white-fleshed selection isolated from Norin (*ex* U.S.A.), gave the highest percentage of marketable tubers.

Agrostology

10. *Pasture grasses*

Work on the improvement of pasture grasses for arid or semi-arid zones like those of Rajasthan and for alpine and sub-alpine regions like those of the Himalayas was initiated. For tracts of the former type, strains of *Chrysopogon montanus, Panicum antidotale* (Blue panic), *Cenchrus setigerus, C. ciliaris* and *Iseilma laxum,* giving higher forage produce per year or showing appreciable growth during specific seasons have been isolated. Moreover, good collection of ecotypes and biotypes of other suitable species such as, *Elyonurus hirsutus, Heteropogon contortus, Sehima nervosum* and *Pennisetum pedicillatum,* has been made. An octoploid of *Chrysopogon montanus* shows good spring growth when the diploid ($n = 10$) remains dormant. In Blue panic, a strain showing winter recovery and another more leafy than normal, have been isolated. Drought or frost resistant strains have been selected in *Cenchrus ciliaris, C. setigerus* and *Panicum coloratum.* Stoloniferous plants have been discovered in *Cenchrus ciliaris* and *C. setigerus* which promote their perennation under drought as also the efficient soil binding action. One of the strains of *C. ciliaris* (E.C. 7382) showed the maximum production (16000 lb.) of roots per acre of 1 ft. deep soil. It is therefore a good soil conservation type.

Male sterile plants have been detected in Blue panic and *Sehima nervosum.*

11. *Vegetable seed testing*

Thirteen hundred seed samples of vegetable crops were registered and tested for their purity, moisture content and germination. Considerable variation was found in respect of these characters in seeds of a given variety offered for sale by different dealers in the country. The data collected are being compiled with a view to formulating standards suited to Indian conditions. Studies directed towards the evolving and evaluating of rapid tests for germination capacity of seeds made further progress. Interesting results were obtained with the use of sodium biselenite, tetrazolium bromide and malachite green. The first two chemicals with a concentration of 0·5 per cent. and duration of 4 to 35 hours and 4 to 8 hours respectively gave very satisfactory results. The indication of seed viability obtained with the use of these chemicals was found to be fully borne out following actual germination tests.

12. *Genetic variability in algae*

The submicroscopic morphology of the diatom wall structures as studied under the electron microscope revealed that there was no homogeneous membrane in diatoms and the walls were variously ornamented, ranging from simple puncta to compound areolae. An interesting case of the occurrence of four pored heterocysts has been recorded for the first time in a blue-green alga, *Nostochopsis lobatus* from Assam. The formation of such heterocysts was found to be a necessary consequence of the transformation of an intercalary vegetative cell flanked by the four adjacent cells. A new species of *Bulbochaete* and a new variety and a form of *Oedogonium* were described from the collections from Kerala. The original diagnosis of Hirn's *Oedogonium perspicuum* has been amended. In *Rhizoclonium hieroglyphicum,* form with narrower filaments had $2n = 24$ while the form with broader filaments had $2n = 36$ chromosomes. Pretreatment with 0·2 per cent. colchicine or 0·0015 M 8-Hydroxyquinoline was found to give good chromosome spreads in propiono-carmine squashes.

The investigation on the nutritional requirements of the green alga, *Selenastrum westii* disclosed that at least 13·6 p.p.m. N was required by the organism for its maximum growth, and a complete inhibition of growth in the absence of any combined nitrogen indicated that the alga was unable to utilize elementary nitrogen. The minimum concentrations of various elements of this organism would have the following proportions in p.p.m. : N = 13·6 : P = 1·8; S = 3·3 ; K = 1·25 ; Ca = 9·8 ; Mg = 1.25. A close correlation has been found between the cell counts and the total chlorophyll content per unit volume and hence it was suggested that the growth of a pigment-producing organism can be measured at any stage of its growth phase by pigment evaluation provided the estimating pigment is closely associated with the basic physiology of the organism.

The nitrogen fixation by *Cylindrospermum sphaerica,* as affected by the changes in the environment was studied. In "dark" cultures the growth of the alga was very slow and the N-fixing capacity remained constant, but it increased in such "dark" cultures as were provided with one g. Sugar/100 ml. medium. The effect of varying H-ion concentrations of the medium showed that a neutral or slightly alkaline medium was preferred by the alga.

Monosomic analysis

By analysing the F_2 populations of Chinese Spring monosomes × N. P. 790 and E. 20, it was found that N. P. 790 has the genes, hd, on chromosome VIII, B_1 on chromosome IX and B_2 on chromosome X and that E. 220 has the gene B_1 on chromosome IX. The presence of the B_2 allel, though inferred by earlier workers, has not so far been clearly demonstrated. Analysis of the segregation for resistance to races H and 13 of yellow rust in the F_2 populations of Chinese Spring monosomes × Cometa Klein showed that chromosomes IV and VI carry genes for resistance to H and that chromosome IX carries a gene conferring resistance to race 13. Monosomic analysis has now been extended to the mutations induced in the varieties N. P. 797, N. P. 798, N. P. 799, N. P. 809 and E. 591.

. *Performance of the radiation induced awned mutants.*

N. P. 809.—Two awned mutants (A6 and A18) gave better yields than the parent strain under high fertility conditions and the awned mutants A1 and A6 performed better than the control under normal fertility conditions. Mutants A6 and A9 gave higher yields than the control N. P. 809 in rod row trials conducted at Simla. The awned mutants were subjected to tests for resistance to individual races of black and brown rusts and they have been found to have rust reactions similar to the control material.

N. P. 797.—True-breeding, fully-awned and early-flowering (4 to 5 days earlier than control) mutants were available. Several mutants, possessing more attractive-looking grains, have also been isolated. All these have been found to give yields either equivalent to or slightly superior to the control. In rust tests two mutants obtained from P_{32} treatment (10 uc. per seed) showed somewhat better resistance to a few races of black and brown rusts.

N. P. 798.—Tests have shown that one awned mutant (F. B. 4) gave a significantly higher yield than the control while in the case of two others there was no difference. One awned mutant gave a lower yield and it seems likely that, besides the awn character, several other changes have been effected by the irradiation treatment. The awned mutants have been found to have the same reactions as the parent strain in respect of several races of black and brown rusts.

N. P. 799.—Twenty-five true breeding awned mutants gave yields superior to that of the control. While the mean yield per plant in the control, N. P. 799, was 5.17 grams, the mutant F. B. 3 gave an yield of 9.23 grams. The rust reaction of the awned mutants was the same as that of the control. Besides the awned mutants, several stiff-strawed plants and mutations affecting ear characteristics have been isolated.

3. *Hybridization between wheat and allied genera*

Advantage was being taken of the chromosome V effect in releasing barriers to inter-genomic pairing, in transferring some segments of rye chromosomes to wheat.

4. *Studies on distant hybridization and embryo culture technique*

As a step towards the successful crossing of widely different parents, standardisation of a suitable medium for experimental culturing of embryos, has been attempted. It

has been found that the addition of yeast extract, indole-acetic acid and gibberelic acid suitable concentrations to the basic White's medium, stimulates the growth of the immatu embryo considerably, delaying its abortion. It has been further found that a significa stimulation of stem and root growth of tomato embryos occurs following the incorpor tion of certain antibiotic substances in the culture media.

Embryological observations have shown that in the case of the jute species cross the endosperm tissue fails to become cellular and degenerates at a very early stage in th growth of the hybrid embryo. Finally, it has been found that more fruits, following cros ing of jute species, are retained on the plant when the female parent is grafted on a stoc from the male parent.

5. *Chromosome length and DNA content in wheat species*

A close correlation between the chromosome length at metaphase and DNA conte of the nuclei in the diploid, tetraploid and hexaploid wheats has been established, thu indicating that these metaphase plates can be used with confidence for calculating the tota chromosome length of the complements. Also, the fact that DNA content in the whea species is directly proportional to the ratio of the total chromatin length suggests that th chromosomes of these three species have a constant content of DNA per unit length and secondly, that they also have the same number of elementary chromosome fibrils.

6. *Studies on fractionation of radiation dose in barley*

Observations made on the effect of fractionated X-ray dose on chromosome aberra tions in barley have provided evidence which suggests that the broken chromosome end remain open for reunion for about 8 hours or more. This conclusion seems to be of in terest from the point of view of the mechanism of biological action of radiations and the use of induced mutations in plant breeding.

7. *Studies on inter-bivalent distribution of chismata in* Delphinium

X-ray treatment of seeds has been successfully used to induce inter-bivalent re-distribu tion of chimata in *Delphinium*. The results, apart from showing a unified control of chiasma formation in the nucleus, emphasise the importance of spontaneously-occuring structura changes of chromosomes in releasing latent variability through redistribution of points of crossing over.

8. *Studies on induction of variation in ornamental plants*

X-ray treatment of seeds and colchicine treatment of seedlings have been successfully employed for the production of mutant and tetraploid forms of a number of garden annuals, which appear more attractive than their respective conrtols. The radiation-induced mutations have been found to be genetically determined, thus indicating that it should be possible to develop new varieties breeding true for the new characters.

9. *Investigations on the relationship between nucleolar and DNA synthesis in chromosomes*

An experimental approach has been developed for the induction of non-synchronised meiotic prophase condensation of different chromosomes in a pollen mother cell. This non-uniform development of the chromosomes in the case of *Delphinium* and *Helipterum* is found to be associated with abnormal nucleolar formation thus indicating a correlated capacity for nucleolar and DNA synthesis.

Plant Physiology

1. *Study of drought resistance in wheat*

Observations on the rate of development of grain and of yellowing of leaves, stem and ear of varieties Pb C 281 and N.P. 720, grown in pot-culture, under normal water supply (W) and intermittent drought during the post-dehiscence period (D), and under normal and late sowing, were reported last year. It was concluded that Pb C 281 appeared to be more drought-resistant by virtue of the slower rate of yellowing of its ear. Carbohydrate analysis of the samples collected during this experiment and carried out during the year under report, gave the following indications :

(a) During the first 3 to 4 weeks after dehiscence, the rate of loss of sugars from the stem was higher under D than under W (it being negligible under W). The similar rate of increase in grain weight under W and D during this period, inspite of quicker yellowing of foliage and stem under D, could perhaps be attributed to greater supply of sugars from the stem. During the subsequent period when the rate of increase in grain weight was higher under W, the rate of loss of sugars from the stem did not correlate with the rate of increase in grain weight; the rate of yellowing of ear was, however, quicker under D and it might be surmised that photosynthetic supply from the ear was the crucial factor during this period.

(b) Comparison of the rates of loss of sugar from the stems of intact and earless shoots indicated that at most 10% of grain weight could be accounted for by the sugar accumulated in the stem.

The following observations from experiments carried out during this year may be noted.

(a) The rate of increase in 1000-grain weight was similar for the first 4 weeks or so after dehiscence in varieties N.P. 826 and N.P. 824, but subsequently the rate in the former variety was higher and so also was the ultimate 1000-grain weight. A similar trend was also noted in varieties Pb C 281 and N.P. 720 among which the former has a higher 1000-grain weight.

(b) The water content of the spikelets (without awns and rachii) was only very slightly reduced under D even when the leaves were at the permanent wilting stage.

2. *Plant hormones*

In a field trial with wheat N. P. 710, alphanaphthylacetic acid (30 p.p.m. with wetting agent) spray, about 3 weeks after sowing did not increase the yield. In a field experiment with 3 varieties of cotton, namely 216 F, 216 F-14 and 320 F, spraying with betanaphthoxyacetic acid (5 p.p.m.) and naphthaleneacetic acid (20 p.p.m.), with wetting agent, did not give any increase in yield, unlike last three seasons. The apparent reason was that the crop was severely attacked by pink bolloworm, inspite of repeated spraying with endrine, and consequently the general level of yield was very low (about 3·5 mds. of seed cotton).

The fibre quality of cotton from the hormone-treated and control crops of the last season was tested at the Technological Laboratory, Matunga, and it was found that the quality of the former was as good as, or perhaps slightly better than, that of the latter.

In the control of *kans* (*Saccharum spontaneum*), CMU—treated beds showed comparatively much sparse growth of the weed even after two years of the hormone application. Guar (*Cyamopsis psoraloides*) grew satisfactorily in the treated beds, thus indicating absence of any residual toxicity of CMU. It may be recalled that toxicity persisted during the previous year.

3. *Plant Nutrition*

In a field experiment with wheat, N. P. 718, with nine treatment combinations (1·75, 3·5 and 7·0 lb. boron/acre application at 10, 37 and 78 days after sowing; since boric acid was received late, its application was delayed by 10 days), application of 3·5 lb. boron 10 days after sowing, was found to increase the grain yield by about 5 md. per acre over control (with yield of 36 md.). It is interesting to note that beneficial effect of boron application has been consistently obtained during the last four seasons in the Botany Division area.

4. *Physiological investigations on autotetraploids of some oil-seed crops* (*I. C. O. C. Scheme*)

In a comparative study of the growth of *Brassica campestris* var. *toria* diploid, T-22 and a new selection of its autotetraploid under two spacings (1′ × 1′ and 1·5′ × 1′ two nitrogen levels (0 and 20 lb. N/acre) and two sowing dates (18-9-1958 and 15-10-1958), it was found that the diploid out-yielded the autotetraploid. The diploid was again superior to the autotetraploid in respect of branching and hence fruit number. Although the yield per plant was higher under wider spacing, the yield per acre was similar under the two spacings; 1·5′ × 1′ may, therefore, be regarded as optimum spacing as the seed rate would be relatively reduced.

Spraying with maleic hydrazide (500 p.p.m.) and parachlorophenoxyacetic acid increased branching and fruit number in the diploid and the autotetraploid. Seed number per siliqua was however adversely affected by maleic hydrazide and thus the increase in yield per plant was obtained only through the other substance.

5. *Coordinated Scheme for investigations on citrus 'dieback'* (*I. C. A. R.*)

Characteristic symptoms of manganese deficiency were obtained in seedlings of Rough Lemon, Sweet Lime, Sour orange and Baduvapuli. The time taken for development of symptoms depended upon the growth rate of the variety—the quicker the growth the earlier the appearance of the symptoms. Vein enlargement and splitting, followed by cork formation, under boron deficiency, was noticed in the seedlings of the rootstocks referred to above.

6. *Coordinated Scheme for pre-soaking seeds in nutrient salts* (*I. C. A. R.*)

It was reported last year that the zinc content of the embryo and endosperm of wheat and of the embryo and testa of cotton was increased on soaking the seeds in zinc sulphate solution (M/400) for 24 hours. The plants from seeds so treated performed better for some time under zinc-deficient culture solutions than control seeds; eventually, however, these plants also developed typical deficiency symptoms and suffered in growth. It would seem that seed-soaking in salts would give only a preliminary advantage to the seedling in the earlier stages in a soil deficient in the particular element.

Plant Introduction

(a) *New Collections*

During the year, 760 samples of seeds and planting materials were introduced from foreign countries and 767 seed samples were collected from within the country. Amongst the more interesting introductions from abroad are : the Brazilian species, *Licania rigida,* which yields oil of high drying quality; West Indian Cherry (*Malpighia punicifolia*) from Puerto Rico; Naranjilla fruit (*Solanum quitoense*) from Colombia; salinity tolerant plants such as *Sanguisorba minor* and *Larrea tridentata* from the U. S. A.; Emerald velvet variety of lawn grass (*Agrostis stolonifera*) from the U.K.; a fodder plant, Russian comfrey (*Symphytum peregrinum*); grape vines from the U. S. A. and Switzerland; ornamental trees from the U. S. A. and Kenya; Solo papaya from Hawaii; and monogerm sugarbeet from the U. S. A. Mention may also be made of a variety of *bajra*—Nango—received through Netherland Embassy; it is remarkable for its long ears measuring about 4 ft.

A survey was undertaken of certain hilly regions of Mysore State and the foot hills of the Nilgiris with a view to collecting wild growing legumes, lesser known economic plants and allied species. A botanical exploration of the eastern Himalayas as well as of Kashmir and the Kulu valley in the north-west was also undertaken. The collection includes leguminous species of *Glycine, Atylosia* and *Crotalaria; Musa* sp.; wild *Colocasias* and *Dioscorea* spp. from the south and wild growing materials of Chicory, Strawberry, several varieties of roses, alfalfa, jasmine, carrot, *Lespedeza, Artemisia* and *Rumex* from the north-western hills.

(b) *Evaluation*

470 cowpea cultures were studied for their suitability as fodder or grain types. Thirty one were found to be promising for fodder purposes. They include Giant (E. C. 8435 *ex* Australia), E. C. 4216 (U. S. A.), Vermello (E. C. 2784 *ex* Brazil) and Chinegra (E. C. 2790 *ex* Australia). Eleven varieties possessing attractive grain size and colour were selected as grain types.

Two newly-introduced fodder oat varieties, *viz.,* Kent and Vernale from Australia appeared promising. The former was tall growing and conspicuously stiff-strawed. The latter is a good late variety with dark green leaves and rather thick culms.

Root sets of the fodder plant known as Russian Comfrey (*Symphytum peregrinum*) were planted. The sets established satisfactorily. The plants were observed to possess high frost-hardiness and heat tolerance. There was, however, considerable mortality due to root-rot caused by *Sclerotium rolfsii.*

From the collection of Soybeans, 11 early to medium maturing varieties, showing good bearing and possessing bold grains, were selected. These included Charlee, Armredo and Willomi.

The recent selection of sweet-potato, Pusa Lal, derived from Norin seedlings, gave in a varietal trial the highest percentage (74·3) of marketable tubers. Its total yield of 18·5 lb. per plot (1/435·6 acre) was next to that of Pusa Safed and Norin P. 11/2 which yielded 23·5 lb. and 22·5 lb. respectively; but amongst the red skinned varieties its performance was the best.

Further selection in Canadian hybrid sunflower was made and the progeny obtained was quite uniform for dwarfness. The oil content in the seeds was estimated to be 26·5%.

Seed Production and Supply

(*i*) *Wheat*

As in the previous years, this Division coordinated the supply of seeds of the New Pusa wheat varieties produced at the Botany and Agronomy Divisions at Delhi, A. R. S. Karnal, B. S. S., Pusa and the Wheat Breeding Substations at Simla and Indore. Owing to the limited facilities available for multiplication of improved wheat varieties at the Institute, only 2420 maunds of seed could be supplied as against the heavy demand of about 21850 maunds.

(*ii*) *Other crops*

The amount of seed distributed is indicated below: This includes seed supplied from Delhi and from the Botanical Substation, Pusa, Bihar.

Crop	Quantity lbs.	ozs.
Paddy	21135	0
Maize	25735	9
Gram	13535	0
Linseed	206	6
Oats	4598	0
Barley	1312	0
Arhar	2763	4
Mung	552	0
Urid	192	0
Lentil	224	0
Sesamum	93	0
Berseem	246	8
Tobacco	0	2
Toria	60	0
Cowpeas	727	0
Vegetables*	7577	9
	78957	6

*(In addition 544 packets of vegetable seeds were also supplied).

Botanical Sub-station, Pusa

Experimental work directed towards the improvement of various crop plants, including cereals, pulses, oilseeds, fibres, vegetables, etc., was carried out in accordance with the approved programme. In addition, nucleus seed of improved N. P. varieties of the more important economic plants was multiplied for distribution; the total amount distributed being nearly 850 maunds. The N. P. wheat varieties multiplied on a large scale included N. P. 710, N. P. 718, N. P. 755, N. P. 758, N. P. 761, N. P. 798 and N. P. 799. The work relating to the maintencance of indigenous and exotic collections was continued.

The results obtained from some of the more important experiments undertaken during the year are briefly described below.

A small-scale trial of promising exotic oat varieties showed the types, Reed-10, Reed-9 and Markton to be consistently high yielding. They gave top yields as in the previous years. The *mung* variety N. P. 23, characterised by attractive grains of uniform size, was found to out-yield all the other N. P. types, as well as some other varieties such as the China types 781 and 49 and the Bihar type, BR 1. In the case of another pulse—*rahar,* the wilt resistant selections Nos. 13, 81 and 86, indicated good yielding ability combined with resistance to disease. The *khesari* (*Lathyrus spp.*) type, I. C. 1422, performed best in a small-scale trial.

The newly selected auto-tetraploid strain of *toria* Elite II, out-yielded the earlier tetraploid type; its yield, however, was somewhat less than that of diploid *sarson.* In linseed, the rust resistant type, N. P. (R. R.) 5, excelled all the new selections in yield. In a trial of jute varieties, I. C. 4142 was found to maintain its superiority with regard to fibre yield. The superior quality of the fibre in this selection has been demonstrated earlier following tests made at the Jute Technological Laboratory, Calcutta. Varieties of a number of important vegetable plants were tested in trials. The tomato varieties—Pusa Ruby, Marglobe, Bisson and Apricure, showed fruit production of 23947 to 28412 lbs. per acre and they out-yielded the local types by as much as 40 to 55%. Several selections from the progeny of a cross between Sioux and Meeruti also performed very well, giving yields of 22412 lbs. and above. Several varieties of peas were found to be very promising; the more important include: I.C. 5397, I.C. 2265, E.C. 4802 and E.C. 9340 among the early maturing types and "Kala nagani" among the varieties having normal maturity.

Programme of work for the year 1959-60

1. Improvement of Indian wheat with special reference to breeding material for different agronomical conditions.
2. Genetics of rust resistance and other characters in wheat.
3. Study of the suitability of N. P. wheats and other breeding material to different agronomical conditions.
4. Study of the milling, baking and *chapati*-making qualities of Indian wheat.
5. Breeding for rust and smut resistance in barley.
6. Breeding for rust resistance and earliness in linseed and wilt resistance and earliness in pigeon-pea (*rahar*).
7. Breeding extra-long staple varieties of cotton.

8. Trials with the recently evolved N. P. strains of crop plants in the different sta of India.
9. Trials with foreign varieties, foreign and indigenous inbreds and hybrids of mai on a regional basis in India.
10. Investigations on the utilization of hybrid vigour in various crop plants includi maize, *jowar, bajra,* onion, *bhindi,* radish, tomato, brinjal and cotton.
11. Breeding for high yield and early ripening in fodder and grain types of *jowar* a *bajra.*
12. Breeding of some pasture grasses and legumes for northern India, with speci reference to suitability to arid, semi-arid and hill regions.
13. Study of the wild relatives of crop plants and their utilization in plant breedin
14. Improvement of chilli, with special reference to the breeding of disease resista varieties.
15. Improvement of some essential oil bearing plants, *e.g.,* cumin, dill, fennel, cor ander and carum.
16. Testing and certification of seeds of vegetable crops.
17. Improvement of ornamental plants by the application of modern techniques lik induction of polyploidy and mutations.
18. Study of the genetic variability in Indian algae with reference to their usefulness t agriculture.
19. Induction and study of polyploidy as a method of crop improvement in Oleiferou Brassicae, linseed, berseem, ornamental plants etc.
20. Cytogenetical studies in various crop plants, including cotton, oilseeds and millet
21. Monosomic analysis of rust resistance and other characters in wheat.
22. Cyto-taxonomical and cyto-ecological studies in some Indian fodder grasses.
23. Induction of mutations in crop plants through the use of chemicals and radia tions from radio-active isotopes, neutrons, X-rays and ultra-violet rays.
24. Studies on the incidence and induction of pollen sterility in crop plants.
25. Application of embryo culture technique to overcome embryo lethality in distan crosses.
26. Improvement of cytological techniques.
27. Study of radiation dose fractionation effect on chromosome aberrations in barley.
28. Investigations on relationship between nucleolar and DNA synthesis in chromo somes.
29. Differential mutability of genes with various mutagenic agents.
30. Physiological studies on resistance to drought and lodging in wheat.
31. Physiological analysis of factors concerned with yield in wheat.
32. Influence of light and temperature on growth and development in wheat.

33. Physiological aspects of plant nutrition in wheat—studies on the relation between varietal differences in the uptake of nutrients.

34. Plant hormones—investigations on their role in growth and development in wheat, cotton, etc. and their use as weedicides.

35. Plant Physiological studies in relation to the die-back disease of citrus.

36. Plant Physiological studies on colchicine-induced autopolyploids of oil-yielding plants, such as, *toria,* linseed, etc.

37. Plant introduction and exploration for indigenous plants of economic value; their maintenance, evaluation and trials at Delhi and other places.

38. Multiplication and distribution of pure seeds of improved N. P. varieties of field and vegetable crops.

REPORT OF THE DIVISION OF ENTOMOLOGY

(*Dr. E. S. Narayanan*)

General

I. Advisory

Requests for the identification of different insects continued to come in as in pr vious years from different parts of the country. During the year, 106 specimens we identified and their names communicated to the respective correspondents. Three hundr and thirty three coloured plates of Indian insect pests and useful birds were supplied different State Departments of Agriculture, Vigyan Mandirs and different colleges a other institutions. One card of *Corcyra* eggs parasitised by *Trichogramma* was sent to t Agricultural Entomologist, Nagpur (Bombay). *Corcyra* eggs and larvae were also supplii to the following Institutions: Zoology Department, Lucknow University; Zoology Depa ment, Delhi University and the Entomology Department, Punjab Universi (Hoshiarpur). Advice was given on the control of the following insect pests or in son cases their important references were supplied to the correspondents from 8 different Stat of India : Peach shoot borer, mango psylla, mango hoppers, mango scale, cardamom thrip white ants, paddy grasshopper, pests of paddy, sugarcane, wheat, vegetables including tom to and cocoanut. Important references on the bollworms of cotton were also supplied to correspondent from Israel. During the year, 1845 samples of seeds were examined, teste and phytosanitary certificates were issued wherever necessary. In addition to the abov one sample of grass *var.* Emerald velvet imported from England, 14 varieties of gra cuttings received from U. S. A. and Switzerland, 6 mango saplings and one orange saplin intended for exporting to Sarawak and about a dozen rhizomes of *Calamus rotang* mea for exporting to U. S. A., were examined and phytosanitary certificates issued whereve required.

II. Donations

At the request of different correspondents, 657 identified insect specimens belongin to different orders were donated to them from the National Pusa Collection. The person or the institutions receiving the donations were the Vigyan Mandir Officers of Nilokhe (Punjab), Masauli (U. P.) and Sehore (M. P.); State Museum and Zoo (Trichur, Keral State), Deputy Director of Agriculture (Jodhpur, Rajasthan); Entomologist (Malari Institute); Principal, Marathwada Agriculture College, Parbani; Rajasthan College o Agriculture, Udaipur; Government College for Women, Trivandrum; S. J. Science Insti tute, Baroda and Principal, Janta High School (Gurgaon).

III. National Pusa Collection

The proper maintenance of the National Pusa Insect Collection was continued wit the timely application of the preservatives and periodic cleaning of the specimens. Thi great National asset has been augmented through collection locally made and also fro other parts of India during the survey tours by the staff. Over two thousand specimen collected have been added to the general collection, pending identification, during the yea The identified main collection has also been augmented by the addition of a number o insects, which were either totally unrepresented or very poorly represented so far. Insec pests of tea and coffee were received from Tocklai Experimental Station, Assam and Coffe Research Station, Balehonnure, Mysore State respectively. Over four hundred specimen were received from B. Tkalcu Esq., of Czechoslovakia. Also one slide of *Velataspis serrulat* Ganguli (Type slide) and a few paratype specimens in a tube were received from Senio

ntomologist, Indian Tea Association, Tocklai Experimental Station, Assam for depositing the National Pusa Collection. Slides of paratypes of *Drepanura falcifera* Bonet (one ide), *Microphysa cingulata* Bonet (3 slides), *Orchesellides boraoi Bonet* (3 slides), *Parara ornata* Bonet (3 slides), were received for incorporation in the National Pusa Collecon from Madrid Museum through Dr. Santopau, Prof. of Botany, St. Xavier College, ombay.

V. Check list of Indian insects

The check lists of the families Chrysomelidae, Nymphalidae, Saturnidae, Cochlididae, poidea, Vespidae, Sphecoidea, Coreidae and Pentatomidae were completed.

. Delhi Intensive Cultivation Scheme

The staff of the Division continued to survey the crop pests and demonstrate control perations against major insect and rodent pests of agricultural crops. Twenty four acres f kharif crops, 6 acres of paddy, about 0·5 acres each of cucurbits and mustard were treated gainst hairy caterpillar, Gundhi bug, Red pumpkin beetle and mustard sawfly respectively. ontrol operations were also undertaken against field rats in about 104 acres under various rops.

Research Projects

Systematic Entomology

. Curculionidae

A study of the Indian Curculionidae showed that there was no adequate key in terature for the ready separation of 31 Indian sub-families. In order to fill up this lacuna he descriptions of the diagonistic characters of these sub-families were translated from the riginal in French and brought together. These were under study in the light of characters bserved in the various species represented in the National Pusa Collection. Permanent prearations of different parts of 8 species of curculionid beetles were made for detailed norphological studies in order to check the existing key.

. Tenebrionidae

The cataloguing of different genera and species of the sub-family Opatrinae was comleted. More than forty species of tenebrionids were collected from Delhi and West Bengal, nd incorporated in the general collection pending further studies.

. Ichneumonidae

The preparation of a monograph of the Indian species of the sub-family Geliane on he lines of Fauna of India, Burma and Ceylon was in progress.

. Chalcididae

Revisionary studies on the sub-family Haltichelinae was continued.

. Tingidae

A new sub-family Phyllogasterotinginae including a new genus *Phyllogasterotingis* nd a new species *acheranthi* was added to the five existing sub-families of Tingoidea. Five ew species, namely, *Urentius cuphorbiae, U. indicus, U. pusaensis, U. sidae* and *U. zizyhifolius* from the Indian region were added to the existing 11 world species of the genus *Irentius* Distant.

6. *Meenoplidae* (*Fulgoroidea*)

Two new species, namely, *Anigrus dehliensis* and *Meenoplus indicus* were added t the seven species of the family Meenoplidae already recorded from the Indian Union.

Taxonomic studies on Indian Encyrtidae, Coccoidea, Apoidea and Aeshnidae wer continued.

Insect Parasitology

1. *Effect of nutrition on the fecundity, longevity and sex-ratio of Bracon gelechiae Ashmea and Trichogramma evanescens minutum Riley, using Corcyra cephalonica Stainton a their host fed on various synthetic diets*

So far the effect of diet on the host has been studied. The growth of *Corcyra* larva on a synthetic diet was compared with their growth on crushed juar. The composition o the synthetic diet was as follows :—

Glucose	50 p.p.m.	Aneurin	25 p.p.m.
Casein	50 p.p.m.	Riboflavin	25 p.p.m.
Cholesterol	1 p.p.m.	Nicotinic acid	25 p.p.m.
Salt mixture	2 p.p.m.	p. amino benzoic acid	25 p.p.m.
Choline chloride	500 p.p.m.	Pyrodoxin	25 p.p.m.
		Folic acid	2·5 p.p.m.

It was observed that the growth on crushed 'juar' was better than that on the synthetic diet throughout the larval period of *Corcyra.*

2. *Biological control of the potato tuber moth infesting potatoes in storage in Patna district*

Preliminary experiments were conducted in godowns at Patna, Bihar Shariff and Sabour by releasing *Bracon gelechiae* and *Trichogramma evanescens minutum* Riley against the caterpillars and eggs, respectively, of *Gnorimoschema operculella* (Zeller). At Patna eggs of the pest were found to have been successfully parasitised by *Trichogramma* and the emergence of the parasites from the host eggs was also observed.

3. *Studies on the chalcid egg parasites of Pyrilla perpusilla* (*Walker*)

Experiments conducted to investigate the phenomenon of superparasitism in *Tetrastichus pyrillae* Craw., showed that superparasitism occurred only when the parasite density increased or the host-density decreased or when the host egg or the parasite egg laid within it did not start its development. It was also observed that even when superparasitism occurred, only one parasite emerged from a single host egg, the others having died before completing their development, *i.e.,* there was an elimination of the 'supernumeraries'.

Insect Ecology and Toxicology

1. *Studies on Control Schedules*

(a) *Control schedule for mustard crop.*—On the basis of three years experiments, it has been finally suggested and sent for publication that about 0·1% *gamma* BHC can be most reasonably applied at an interval of 20 to 30 days, depending on the rate at which the aphid population builds up in a particular season.

(b) *Control schedule for maize crop.*—Two sprayings with 0·1% DDT, 0·075% *gamma* BHC, 0·075% endrin and 0·05% parathion + 0·1% DDT mixture (1·1) were given during the whole season. The average yield of maize seeds per plot of 1000 sq. ft. in dif-

erent treatments was: mixture of parathion and DDT 30·25 lbs., *gamma* BHC 28·25 lbs., ndrin 26·6 lbs., DDT 21·75 lbs. and control 14·0 lbs.

(c) *Control schedule for cotton crop.*—In all five sprayings with 0·1% *gamma* BHC, ·05% parathion, 0·05% diazinon, 0·50% endrin and 0·05% systox (replaced by meta-systox n the fifth spraying) were given in the season. The average yield of cotton per plot (55′ × 20′) was endrin 13·6 lbs., parathion 12·6 lbs., *gamma* BHC 9·0 lbs., diazinon 9·0 lbs., ystox 9·0 lbs. and control 9·0 lbs.

. Effect of endrin sprays on the population balance in cotton crop

The experimental cotton crop was sprayed five times with 0·1% endrin at the increasing rate of ½ oz. to 1½ ozs. per acre. After the fifth spraying the population of jassids, thrips, whiteflies, mites, aphids and spotted bollworms were reduced by 80%, 95%, 70%, 36%, 09:6% and 45% respectively and the population of pink bollworms went up by 60%.

3. *Bioassay of Insecticides*

(a) *With Hieroglyphus nigrorepletus.*—*Gamma* BHC, chlordane and dieldrin were applied on the soil surface of pots, containing eggs of "phadka", @ 1, 2 and 3 lbs./acre and also on the surface of bunds in the field @ 3 lbs./acre. In the case of pots and bunds treated with *gamma* BHC, all the nymphs died immediately after hatching, while in the other two treatments, the nymphs, which emerged died within 24 hours. In the laboratory trials the order of toxicity of different insecticidal dusts against "phadka" adults was found to be: endrin > lindane > dieldrin > aldrin > chlordane > toxaphene.

(b) *With Potato Tuber moth.*—Potatoes infested with larvae of *Gnorimoschema operculella* (Zeller) were fumigated with different fumigants for 24 hours. Taking M. L. C. value of carbon disulphide as 1, the relative toxicity of (a) methyl bromide, (b) a mixture of carbon disulphide and carbon tetrachloride and (c) carbon tetrachloride only were found to be respectively, 0·92, 0·41 and 0·12.

(c) *With Tribolium castaneum.*—Adults were fumigated with (a) carbon tetrachloride, (b) ethylene dichloride and (c) EDCT mixture in 500 ml. flasks filled with 133, 266 and 399 gms. of wheat per flask. Carbon tetrachloride was found to be the most effective fumigant followed by EDCT mixture and ethylene dichloride. In another experiment with 8 litre flasks filled with 5, 10 and 15 lbs. of wheat, it was found that with the increase in the quantity of wheat, the dose of the fumigant had to be increased considerably to get the same results.

(d) *Studies on the phytotoxicity of insecticides.*—(i) Grapes of 'arab-e-shahi' variety were sprayed with 0·25% malathion, 0·1% aldrin, 0·09% parathion, 0·25% *gamma* BHC and 1·0% DDT emulsions. No phytotoxicity was observed 2 weeks after the treatments.

(ii) Citrus saplings of Mandarian variety were sprayed with 0·46% parathion, 2·0% dieldrin, 5·0% DDT, 3·0% *gamma* BHC, 3·0% aldrin, 1·5% malathion and 0·3% diazinon. No phytotoxicity was observed.

(iii) Citrus saplings of the same variety were fumigated with HCN @ 3 and 5 mg./litre for 2 hours both in the sun and shade. The saplings treated and kept in the sunlight showed phytotoxicity in both the concentrations while those fumigated in shade showed slight scorching of leaves in the 5 mg./litre dose.

(iv) No phytotoxicity was observed, two weeks after spraying of plum saplings, with emulsions of 1·25% malathion, 2·5% aldrin, 0·46% parathion, 2·5% *gamma* BHC, 4·0% DDT, 2·0% dieldrin and 0·3% diazinon.

(v) Uninfested potatoes were repeatedly fumigated at weekly intervals with CS methyl bromide, mixture of CS and Ccl . No apparent damage was observed in th fumigated potatoes after three treatments.

(vi) Different lots of paddy (NP130 & NP40) and maize yellow 2 treated with DD BHC and dieldrin dusts and fumigated with CS_2, HCN and EDCT mixture, were store at Delhi, Pusa (Bihar) and Karnal (Punjab). All the dust treatments were found effecti in the case of maize in which the infestation was checked to an appreciable degree and th viability was also not impaired.

A. Second Five-year Plan Schemes

I. Entomological investigations with the help of radioactive isotopes

(a) *Effect of radioactivity on the rate of reproduction, longevity and fecundity of a insect parasite (Bracon gelechiae Ashmead) and its laboratory host (Corcyra cephalonic Stainton).*—Irradiation of freshly laid eggs of *B. gelechiae* with beta radiation dosage of 200 3000 and 4000 mrep/hr. and that of pupae with 400 to 4000 mrep/hr. dosage for 24 hour was undertaken. In the former the viability of the eggs was somewhat impaired in th 4000 mrep/ hr. dose in the parent and first generations and in the latter there was no ap parent effect on the adult emergence in the parent generation, but the successful com pletion or development was slightly affected in all the dosages in the first generation The adverse effect in both the cases did not pass on to the second generation. I another experiment full grown caterpillars of *C. cephalonica* were irradiated with 555, 1111 2222 and 3333 mrep/hr. dosages for 24 hours, and it was observed that 1111 mrep/hr. dos was useful to the insect on the whole.

(b) *Fate of Systemic insecticides in insect body and in plants.*—Experiments were undertaken to study the pick-up of radioactive 'schradan' by the adults of *Dysdercus koenigi* Fabr. Assaying of the various parts of the insect indicated that 'schradan' was readily picke up by it from the insecticidal film and distributed in all parts of the body. In the case o alimentary canal it was accumulated mostly in the fore and hind gut.

II. Biological Testing and Certification of Insecticides.

Commercial samples of aldrin, endrin, *gamma* BHC and endrin containing wate were received from different sources and were biologically tested and compared for their toxicity with corresponding laboratory made formulations. Nine samples of chemicals received from the Chemistry Division, I.A.R.I., and two samples of preparations received from the National Chemical Laboratory were screened and tested for their insecticidal and repellant properties.

Against the grubs of *Hypera variabilis,* dieldrin, methyl parathion, isodrin, aldrin, endrin, lindane, malathion, chlordane and toxaphene were found to be respectively 62·5, 39·7, 32·8, 20·0, 14·8, 12·3, 8:6, 4·6 and 0·64 times as toxic as p,p' DDT. Against the larvae of *Prodenia litura* the order of toxicity of different insecticides was: isodrin > endrin > thiodan > parathion > aldrin > dieldrin > DDT > heptachlor > pyrethrins > lindane > malathion > thimet > diazinon > toxaphene > chlordane > thanite > nicotine sulphate. Against the adults of *Dysdercus koenigii,* the order of toxicity of different insecticides was: Parathion > dieldrin > *gamma* BHC > endrin > thimet > diazinon > malathion > pyrethrins > isodrin > thiodan > p-p' DDT > aldrin > heptachlor > chlordane > toxaphene > nicotine sulphate. Similarly against the larvae of *Diacrisia obliqua* the order

toxicity was: thiodan ≥ parathion > pyrethrin > dieldrin > endrin > heptachlor > odrin > aldrin > lindane > toxaphene > chlordane > thimet > malathion > p-p' DDT > icotine sulphate.

I. Ecological studies on stored grain pests.

(a) Studies on the rate and percentage development of *Trogoderma granarium* under fferent ecological conditions *viz.*, under combinations of 30°, 35°, 40° and 45°C tempera-ures and 100%, 90%, 75%, 60%, 45% and 30% relative humidities were completed.

(b) Initially fumigated wheat stored for ten months in (a) metallic bin and (b) an arthen structure with polythene film of 700 gauze incorporated in its walls, showed no nfestation. There was, on the other hand, 18% infestation in an earthen structure without olythene film.

V. Seed Testing

(a) One thousand eight hundred and forty-five samples of seeds were examined, test-d and phytosanitary certificates issued wherever necessary.

(b) Seventy three samples of vegetable seeds namely, lady's finger, tomato, brinjal, umpkin, round gourd, pea, 'tinda', water melon, musk melon and 'chapni kadu', collected rom the markets in the Punjab, U. P., Bombay, Mysore and Andhra Pradesh States were xamined for the infestation of insect pests. Examination of cucurbit seeds showed that bout 5% of the seeds in some samples were damaged by *Rhizopertha dominica.*

V. Locust Toxicology

Experiments were started to segregate a strain of *Schistocerca gregaria,* resistant to *gamma* BHC.

Work was started on chromatographic separation of the metabolic products of DDT. DDE has been recovered from the DDT treated hoppers.

A synthetic diet consisting of dry cabbage leaf powder, wheat, bran, milk powder and yeast (2:2:2:1) was successfully used for rearing the desert locust.

VI. Indian Honey Bee

The little Indian bee *Apis florea* was found to have a mean tongue length of 3:2708 ± 0:0038 mm., the number of hooks per hind wing was 10·96 0·0427, the number of cells per four linear cms. 13·526 and per sq. cm. 13·210 and the average thickness of the worker brood comb 16·82 mm.

Seed setting of 'saunf' (*Foeniculum vulgare*) in voil cloth sleeves was found to be 5·475% only as compared to 84·93% in open, showing that the setting increased immensely when pollinating insects were allowed free access to 'saunf' flowers. It was observed that among the insect pollinators of 'barseem', *Apis indica* constituted 63·5% and *A. dorsata* 21%. Most of the other insect visitors were found to belong to the orders of Diptera and Hemiptera.

VII. Insect Physiology.

(1) *Plant resistance to insect pests.*—Work was in progress on the effect of nutrients and micronutrients on the metabolism of insect pests of major crops. Sorghum plants were subjected to infestation by newly hatched larvae of *Chilo zonellus* with a view to find out the behaviour of first stage larvae in relation to feeding sites. It was observed that the larvae have a tendency to go towards the central whorl irrespective of their place of in-

oculation and they fed on the soft tissues of central leaf for two or three days and then bo into the stem. Their habit of feeding on leaves agrees with another finding that a leaf fact is vitally essential in an artificial diet for rearing larvae of this insect.

(2) *Nutrition of insect associated with plant products.*—Experiments were conducte with various plant products in order to investigate the nutritive value of these materials f *Tribolium castaneum*. It was observed that the larvae of this insect completed their d velopment on an unusual food like cotton seeds, but did not survive on ginger, cotton c cake, 'copra' and coffee. This shows that *Tribolium castaneum* can become a pest of cotto seeds under certain conditions.

Studies were undertaken to find out the lipid requirement of the larvae of *Lasioderm serricorne* with symbionts and without symbionts with a view to examine the role playe by micro-organisms in their physiology. It was observed that larvae with or without sym bionts could grow fairly well in different lipids and even also without a source of lipid. was observed that the larvae of *Tribolium, Lasioderma, Corcyra* and *Trogoderma* coul develop into normal adults on chillies but the larvae of *Latheticus, Laemophloeus* could no survive for a few days even on chillies containing 5% yeast. This shows that chillies a complete diet for *Tribolium, Lasioderma, Corcyra* and *Trogoderma* but some factor there which is unfavourable to *Latheticus* and *Laemophloeus*.

(3) *Rearing of beneficial insects including parasites in artificially compounded an seminatural diets.*—Adults of *Bracon gelechiae* were fed on various sugars and it was obser ed that on sorbose, glucose, meleziotose, fructose, arabinose, dulcitol, lactose and raffinos the parasite could survive for 6-7 days while on pure water the survival was 4-5 days. Parti success was achieved when larvae of *Bracon gelechiae* were reared on semi-solid diet co taining biotin, choline, nucleic acid, tryptophan and casein hydrolysate and also extract fro *Corcyra* larvae.

(4) *Symbiosis and its physiological significance.*—Attempts were made to eliminat symbiotes from certain hemipterans by centrifugation of eggs and feeding antibiotics Experiments were also performed to rear these insects from egg to adult in laboratory Various methods were tried to rear *Dysdercus* sp. on a chemically defined medium; it wa observed that the nymphs could live for nearly 30 days on a diet consisting of calcium caseinate, glucose, starch, yeast, salt mixture, cholesterol and cotton seed oil, offered in th form of pellets. This diet is complete for the development of many insects but in the cas of this insect, it seems, some factor is missing, which was under investigation. Anatomica studies of *Halys dentatus* (pentatomid bug) revealed four pink coloured mycetomes around 4th ventriculus of the midgut.

(5) *Investigations of digestive physiology of insects.*—Digestive physiology of *Earias fabia* larvae was worked out. It was found out that its midgut secretes amylase, maltase lipase, lactose and protease.

(6) *Physiological studies on fruit flies with special reference to nutritional require ments.*—New techniques of rearing *Dacus cucurbitae* on polished rice and milk agar media were developed. Studies on the responses of the larvae of these flies to various fruits under septic and aseptic conditions were undertaken and it was found out that the larvae could complete their development under septic conditions. Anatomical studies of *Dacus cucurbitae* revealed that mycetomes contained "rod shaped" bacteria. Work with a view to for-

ulate a basic diet for the larvae showed that the larvae of *Dacus cucurbitae* could not grow any of the mixtures tried, except for a limited success in a mixture which had water soluble portion of yeast.

III. Survey of Beneficial Parasites and Predators of Pests of Agricultural crops in Indian Union

Seventeen species of parasites and predators were reared from different insect pests. ut of these, five were new species.

The biology and morphology of the immature stages of a scelionid egg parasite of *agrada cruciferarum* were studied. Studies were also in progress on its longevity, fecundity, x-ratio and systematics.

Taxonomic work on the Indian Mymaridae was continued. A catalogue of the known ecies of the world of the sub-family Aphidiinae (Family Braconidae) was prepared.

Mass rearing of hosts and parasistes.—About 1,90,000 *Corcyra* moths emerged and uid about 335·00 c.c. of eggs, which were used for the mass multiplication of *Trichogramma* nd other parasites as well as for maintaining the *Corcyra* culture. About 18,20,000 *Trichogramma* parasites were bred during the period. The cultures of *Apanteles angaleti, Bracon gelechiae, B. brevicornis and Glyptomorpha deesae* were maintained.

B. I. C. A. R. Schemes

. Biology and control of termites affecting agricultural crops

Field experiments on the control of termites, infesting sugarcane, cotton and wheat vere carried out. There was practically no termite damage in sugarcane and cotton. In xperiments on the control of termites infesting wheat (NP. 718) sown under unirrigated onditions, the damage in plots treated with 5% aldrin used @ 40 lbs./ acre was 6·2% as gainst 26·4% in control. The field experiment on the varietal resistance of wheat to termite ttack was laid out. The biology of *Odontotermes* sp. was studied in the laboratory. The olony of termites started with a pair collected at the end of July progressed satisfactorily for bout two months after which it gradually dwindled.

2. Exploration of toxicity hazards in the use of modern insecticides against cattle and human beings

Studies on the persistence of DDT and BHC on different vegetable crops showed that here was quite a quick decline in the amount of residue in most cases; the spray residues were comparatively more and persisted longer than the dust residues.

Studies were also undertaken on the risk involved in the contamination with BHC to grains stored in sacks dusted with 5% BHC at the rate of 6 ozs./100 sq. feet. It was observed hat BHC residues in the grains close to the surface dusted were higher than the tolerance imits suggested by F. D. A. up to two months of storage.

3. Biology and nutrition of insect pests of agricultural importance

A technique was successfully devised for rearing *Sitophilus oryzae* and *Bruchus* sp. on hemically known diets. The reaction of *Laemophloeus minutus* adults and larvae was tudied towards whole and broken grains.

Freshly hatched larvae of *Chilo zonellus* were successfully reared on an artificial diet ontaining various growth factors.

Experiments concerning vitamins and sterol requirement and the toxicity of various imple and complex carbohydrates with the larvae of *Trogoderma granarium* were conduct-

ed. An investigation into the carbohydrate and amino acid requirement of *Lasioderma se ricorne* and *Stegobium paniceium* was undertaken. Isolation and culturing of bacteria fro the gut of *Cletus* sp., *Homeocerus* sp. and *Riptortus* sp. were made.

Programme of work for 1959-60

A. Section of Parasitology

(1) Study of biology and bionomics of insect parasites and predators.
(2) Fundamental studies on insect parasitism.
(3) Preparation of catalogues of important groups of parasites.
(4) Mass breeding of parasites.
(5) Field experiments on the biological control of *Chilo zonellus* Swinhoe on juar
(6) Field experiments on the biological control of the pink bollworm of cotton.
(7) Survey and collection of parasites and predators of pests of Agricultural Crops i the Indian Union, and their identification and attempts to mass-breed whereve possible.
(8) Biological control of potato tuber moth, *Gnorimoschema operculella* in Patn district.

B. Section of insect Ecology and Toxicology

(1) Studies on the development and distribution of insects under different ecologica conditions.
(2) Studies on population determination and assessment of damage.
(3) Effect of chemical control on the biological balance of cultivated crops.
(4) Factors responsible for variation in the susceptibility of insects and the toxicity c insecticides.
(5) Bioassay of insecticides.
(6) Toxicological and ecological studies on the Desert Locust.
(7) Studies on the effect of contact insecticides (DDT, BHC, dieldrin) and fumigant (CS , HCN and chlorosol) on the insect infestation in stored grains and th viability of seeds.
(8) Field and laboratory tests with pyrethrins against important crop and stored grai pests.
(9) Laboratory tests on the chemical control of the Desert Locust in flight and *situ*.
(10) Oviposition response by the Desert Locust.
(11) Phenological observations on crop pests.
(12) Plant Introduction.
(13) I. C. A. R. Termite Research Scheme.
(14) I. C. A. R. Scheme on toxicity hazards of modern organic insecticides to huma beings and cattle.

C. Section of Systematic Entomology

(1) Taxonomy of Indian Curculionidae (Coleoptera).
(2) Taxonomy of Indian Aeshnidae (Odonata).
(3) Taxonomy of Indian Ichneumonidae (Hymenoptera).
(4) Revisionary studies on Chalcididae (Hymenoptera).

(5) Taxonomy of Indian Tenebrionidae (Coleoptera).

(6) Studies on Indian Coccoidea (Rhynchota).

(7) Studies on Indian Apoidea (Hymenoptera).

(8) Studies on Indian Tingoidea (Rhynchota).

. *Section of Insect Physiology*

(1) Plant Breeding for resistance to insect pests. Effect of nutrients and micronutrients on the metabolism of insect pests of major crops.

(2) Nutrition of insects associated with plant products.

(3) Rearing of beneficial insects including parasites in artificially compounded and seminatural diet.

(4) Symbiosis and its physiological significance.

(5) Investigations on digestive physiology of insects.

(6) Physiological studies on fruit-flies with special reference to nutritional requirements.

(7) I. C. A. R. Scheme on the nutritional and biological studies on insects of agricultural importance.

. *Schemes under the Second five-year plan*

(1) Biological testing and certification of insecticides.

(2) Ecological studies on the insect pests of stored grain.

(3) Testing and certification of improved varieties of seeds.

(4) Locust toxicology.

(5) Entomological investigations with radioactive isotopes.

(6) Bee-Keeping.

(7) Survey of beneficial parasites and predators of pests of crops in the Indian Union.

REPORT OF THE DIVISION OF HORTICULTURE

(*Dr. S. Krishnamurthi*)

The Division of Horticulture was established as a scheme under the Second F Year Plan and during the third year of its inception the research activities have expanc considerably. The work under progress covers three main fields of horticulture *viz.*, Por logy, Vegetables and Fruit and Vegetable Preservation and there is also a small unit ornamental gardening which devotes attention on roses and other ornamental plants.

Pomology Section

1. *Survey, collection and evaluation of superior germ plasm in tree fruits*

Several orchards of citrus and mango were surveyed in the Punjab and superior stra have been isolated. Three polyembryonic varieties (*Goa, Pahutan* and *Kurukkan*) ha been collected from South India to study their performance under Delhi conditions and a for rootstock purposes. In citrus, seeds of Shamouti orange were received from Israel a three rootstock species viz., *Herale, Tangor* and *Gabbuchinee,* were obtained from Koc (Andhra Pradesh).

A papaya variety, namely, *Barwani,* obtained from Rajasthan proved to be a promisi variety for commercial exploitation. Out of a total population of 204 plants raised from se sown *in situ,* there was only one male plant. The female and bi-sexual plants totalled 74 a 129 respectively. Very low percentage of male plants is an important characteristic. T fruits of this variety were of superior quality and two flesh colours *viz.*, deep orange a yellow, were noted and the seeds from these fruits have been isolated. The total sol percentage ranged from 10 to 12 in the former and 14 in the latter. This variety has n been released for commercial cultivation in Delhi and adjoining States. Three more stra of papaya were obtained *viz.*, Red papaya from Coimbatore, Paterson from Howrah a another unnamed variety from Indonesia and were under performance tests.

2. *Performance of sub-tropical and tropical fruit species and varieties under Delhi conditi*

Tree-wise record of the different varieties of citrus, mango, guava, grape, loq *phalsa,* etc., was made on the growth, flowering and fruiting behaviour. These studies h been initiated during the year under report to assess the performance of the different varie and species under Delhi conditions on the basis of data collected for three or more succes years.

3. *Improvement of grapes through hybridization with special reference to earliness, y and fruit quality.*

Using Pusa Seedless, a local selection made by the Horticulture Division, as male urent, crosses were made with different choice seeded varieties, which have other desirable haracters, *viz.*, prolificity and earliness in bearing (*Bhokri*), good quality bunches (*Kandhari*) and sweet berries (*Gros Colman*). Seed set was noted in all the combinations. Seeds ere collected from the crosses made with *Gros Colman* and *Kandhari* varieties and will be wn in February, 1960.

Three more varieties from California were added to the collection and the total number of grape varieties now under observation was 155.

Induction and utilization of polyploidy for the improvement of grapes with special reference to seedlessness and other desirable qualities

New technique was attempted for induction of polyploidy in mature vines. The pper three lateral buds in young shoots were treated with 0.5% colchicine solution prepared n 10% glycerine and gibberellic acid (10 ppm.). *Bhokri, Kandhari* and *Anab-e-Shahi* arieties were treated with colchicine at the concentrations of 0.5% and 0.75% and cuttings f *Pusa Seedless, Bhokri, Anab-e-Shahi* and *Kandhari* were treated at 0.2%, 0.3% and 0.5% oncentrations in the nursery. Some promising shoots of suspected polyploid characters have been isolated on the basis of morphological characters. Further observations were under progress.

Improvement of guava by selection and hybridization with special reference to yield and fruit quality.

In an acre of seedling plantation of *Safeda* variety, variations in fruit shape, size and quality were studied during December-January and five trees have been marked out for heir superior quality fruits which will be tested again before they are utilised for multiplication as superior strains.

Improvement of mango by selection and hybridization

Preliminary studies were conducted on the technique of emasculation before undertaking the actual crossing. The need for removal of staminodes, apart from the fertile stamen, was studied. It was noted that when the flowers were bagged and functional stamen alone was removed, leaving the staminodes intact, from 8.33 to 12.80 per cent of the flowers set fruit, indicating that it was necessary to remove the staminodes also.

Variety	Number of flowers emasculated per panicle	Number of fruit-set	Percentage of fruit-set
Dashehri	94	8	8·61
Dashehri	127	14	11·02
Dashehri	107	11	12·80
Langra	84	7	8·33

The data indicate that staminodes did produce some fertile pollen which was responsible for the fruit set.

7. Studies on morphology, floral biology and cytology of tree fruits.

(1) *Pomegranate.*—Seven varieties *viz., Dholka, Double Flower, GB*-1, *Japanese Dwarf, Kandhari, Muscat White* and *Patiala* were taken up for investigations and a key for the identification of pomegranate varieties on the basis of morphological characters was formulated. Stomatal indices of all the varieties were determined and their correlation with arid, semi-arid, and moist region ecotypes was found. *Kandhari* and *Patiala,* well known varieties of northern arid regions, had stomatal indices 24.2 and 24.3 respectively. *Dholka, Muscat White,* and *Japanese Dwarf* of semi-arid regions showed stomatal indices 21.2, 21.3 and 21.2 respectively and *GB*-1 of moist regions of Bombay recorded stomatal index of 19.6.

Inflorescence and flowering habit were found to vary in manifestation but in general it was determined to be dichasial cyme. Percentage of hermaphrodite flowers was found highest in the *Japanese Dwarf* (53.85) and lowest in *Kandhari* and GB-1 (25 and 25.45). No hermaphrodite flower was recorded in *Double Flower* variety. Maximum anthesis was found related with temperature and in the case of *Muscat White* optimum temperature range was found to be 37°-38° C. Stigma attained maturity one day before anthesis and receptivity remained at peak on the same and second day after anthesis and it gradually went down till the third day after which it abruptly sank into non-receptivity. Pollination studies showed that both self and cross-pollination were possible. In *Muscat White,* 46 per cent fruit-set was obtained by self-pollination and cross-pollination and the cross-pollination improved the fruit-set to 67.92 per cent.

Some floral abnormalities *viz.,* flower without petals, modified stamens, abnormal stigma, abnormal calyx etc., were observed in different varieties. The occurrence of petal in the ovarian cavity in place of ovules in the *Double Flower* variety was noted for the first time in *Punica.*

For cytological studies, a satisfactory technique for squashing and smearing was standardised. The swarm of cell inclusions (mostly tannic acid) which impeded the observations were removed by boiling with hydrogen peroxide with a pinch of mild alkali (lithium carbonate) added to it or treating with cold perchloric acid prior to staining. Both 2n = 16 (*Dholka, GB*-1, *Kandhari, Muscat White* and *Patiala*) and 2n=18 (*Double Flower*) chromosome types were detected in pomegranate varieties. All the somatic chromosomes in the six varieties studied revealed to possess median primary constriction and at least one pair of chromosomes was larger than the rest. Meiotic studies showed clear eight bi-valents at first metaphase and subsequent stages were found to be normal.

(ii) *Plum.*—The taxonomy of ten plum varieties was studied in detail and they were found to belong to both American and Japanese groups. The floral biology of six varieties were carried out in detail. The time of flowering of the various varieties was seen to overlap excepting in the case of *Howe* and *Excelsior.* Pollination studies indicated that only *Aloocha Black* was self fertile. Studies on stigma receptivity showed that maximum fruit-set was noted when pollinated a day earlier to anthesis.

Cytological examination of the somatic cells showed that all the varieties grown here were diploids and the chromosome number was found to be 2n = 16.

8. *Induction of mutations in tree fruits through X-rays, fast neutrons and radioactive isotopes (in coordination with cytogenetics section of the Botany Division).*

Experiments were initiated with sweet lime and bud sticks were selected from a single parent tree of sweet lime during June, 1959 and buds were exposed to different dosages of X-rays as detailed below. Treated buds were then topworked on 7-year old sweet lime trees.

Tree No.	7200r	14000r	21000r	Control	Total
$R_1 T_1$	5	5	5	5	20
$R_1 T_2$	5	5	5	5	20
$R_1 T_3$	5	5	5	5	20
$R_1 T_4$	5	5	5	5	20
$R_1 T_5$	5	5	5	5	20
$R_1 T^6$	..	..	13	..	13
	25	25	38	25	113

Observations on bud take etc., were in progress.

9. *Studies on blossom biology and sex-ratio in mango*

Blossom biological studies were initiated in *Dashehri, Chausa* and *Kishen Bhog*. During the year under report data on the nature of panicles and their development and percentage of hermaphrodite flowers were recorded. In the varieties *Dashehri, Chausa* and *Kishen Bhog*, the perfect flowers noted were 28.81%, 43.05% and 23.62% respectively. Further observations were in progress and data would be collected for two more seasons when the productivity character of the varieties can be adequately assessed.

Taxonomical studies.—Detailed studies were conducted on the various citrus species and varieties in the orchard. From the studies, it was observed that sweet lime deserved a separate specific status, since it is entirely different in characters from the kagzi lime. Some varieties of lemon like *Genoa, Nepali Oblong* and *Hill* lemon, were found to possess characters of citron also. In sweet orange, grapefruit and mandarins, descriptions of different varieties agreed with those conclusions made by Swingle and Webber (1946). Another Indian species Rangpur lime was found to be a hybrid between mandarin and rough lemon.

In the mango, the leaf and the floral characters were noted in the varieties *Dashehri, Samar Behisht Chausa, Langra, Bombay Green* and *Kishen Bhog*.

Studies were also made in the stone fruits of the temperate group. Visits were made to the Hill Fruit Research Stations and different varieties studied were:—

Plum.—Early, Methley, Santa Rosa, Climax, Beauty, Satsuma, Yellow Maynard and Alu Bukhara.

Apricot.—New Castle, Safeda, Stark Early Orange, Char Magaz, Safeda and Para Chinar.

Peach.—World's Earliest.

10. *Studies on propagation methods*

Phalsa.—Series of investigations were conducted to standardize methods of clonal propagation. Different methods of vegetative propagation and significant success was achieved with layering and budding:—

Months of operation	Method used	Number of plants used	Number of plants succeeded	Percentage of success
May	Ring budding	17	11	65
August	Ground layering (with seradix 30)	50	40	80
August	Ground layering	50	30	60

The data indicate that both layering and budding hold out promise for commercial adoption. Further investigations were under progress for determining the optimum season or seasons of operation.

Guava : A series of experiments were conducted on the success of budding in two guava varieties. In *Chittidar* variety, April and May budding gave highest success (64% and 56% respectively) with the soaking of buds in indolebutyric acid at 10 ppm for 10 minutes. Untreated buds gave a success of 56% and 52% (bud take) respectively in April and May. In the variety *Seedless,* pre-treatment of buds with plant regulators showed deleterious effects on the percentage of bud take and untreated buds gave 68% success.

11. *Standardization of rootstocks in citrus*

A collection was made for the study of different species and varieties of citrus for their value as rootstocks. In all 31 species and varieties were collected from Andhra Pradesh, Assam and Punjab including those varieties which were available at I. A. R. I. orchards. Seeds were sown in the beds and the range of polyembryony was noted in each variety.

Name of the variety or species	No. of embryo	Range of embryos	Name of the variety or species	No. of embryos	Range of embryos
Grapefruit (C. paradisi)			*Lemons (C. limon)*		
Duncan	2·3	1 to 5	Italian Round	2·2	1 to 3
Saharanpur Special	2·4	1 to 4	Meyer Lemon	1·4	1 to 2
Foster Pink	2·1	1 to 3	Nepali Oblong	1·2	1 to 2
Poona budded	2·4	1 to 4	Columbia	1·1	1 to 2
Sweet orange (C. sinensis)			*Others*		
Valencia late	2·5	1 to 4	Jamberi	5·1	1 to 6
Tardiff	2·5	1 to 5	Karna Khatta	4·6	1 to 6
Joppa	2·4	1 to 3	Soh myndong	2·6	1 to 4
Dulcis	2·5	1 to 4	Kata Jamir	2·6	1 to 4
Mosambi	2·3	1 to 4	Ada Jamir	2·2	1 to 3
			Rababtenga	1·0	1
Mandarin (C. reticulata)			China Hazara	2·4	1 to 4
Beauty & Florida	3·4	2 to 5	Karun jamir	1·2	1 to 3
Natal tight	3·1	1 to 5			
Hill mandarin	3·4	1 to 4			
Khasi mandarin	3·1	1 to 4			

Further studies on the nursery behaviour of these rootstocks were in progress.

Standardization of rootstock in mango.—Three polyembryonic varieties, namely *Goa, Pahutan* and *Kurukkan* were collected from *Kodur* (Andhra Pradesh) and the range of polyembryony in them was noted.

Variety	Number of stones sown	Number of seedlings germinated	Average number of seedlings per seed	Range of seedlings per seed
Goa	34	11	1·09	1 to 2
Pahutan	28	12	1·08	1 to 2
Kurukkan	41	11	1·45	1 to 4

12. *Plant regulator studies in fruit trees*

With the encouraging response of gibberellic acid on the *Pusa Seedless* variety obtained last year, seeded grape varieties namely *Bhokri, Black Muscat, Black Hamburg* and *Hussaini* were treated with spray applications of gibberellic acid (75 ppm). In this case flower clusters were thinned before hand to 33% and then sprayed with the plant regulators.

Vegetable Section

13. *Survey and collection of cultivated and wild species and varieties of both indigenous and exotic vegetables and assessment of variability in them and their utilization for breeding*

A collection of 235 strains of different vegetables was made from all over India during the year, making the total of 675 strains so far collected. The morphological characters of each strain are being studied.

14. *Studies on sex ratio in cucurbits*

Cucumber (*Cucumis sativas L.*).—Studies on the sex ratio in six varieties of cucumbers were carried out, to determine (i) the ratio of staminate to pistillate flowers for each variety and then to select varieties with high pistillate to staminate flower ratio; (ii) whether the node number is a constant varietal character; (iii) the relation between the node number and the days of pistillate flower on the main axis; and (iv) node number as a criterion of sex tendency. The results as recorded are presented in the table given below :—

Variety	July crop		February crop	
	Node no. appearance of first female flower on main axis	Pistillate staminate ratio	Node no. appearance of first female flower on main axis	Pistillate staminate ratio
A & C	21·745	0·044	18·912	0·058
Straight-8	13·080	0·144	12·995	0·157
China	26·497	0·021	25·327	0·024
Fordhook famous	38·497	0·008	17·162	0·066
Khira Poona	14·665	0·073	5·745	0·636
I.C.4079	11·497	0·144	7·582	0·208
SEm	±2·34	±0·032	±1·472	±0·065
CD at 5%	6·622	0·096	4·435	0·196

In the February grown crop, the variety Khira Poona, was found to have the highest tendency towards the female sex expression, whereas, in the July grown crop Straight-8 and I.C. 4079 had the highest tendency. From the data in the table it is quite clear that the node number in which the first female flower appeared was inversely proportional to the pistillate staminate ratio. Further study is in progress.

15. *Studies on hybrid vigour*

Brinjal (*Solanum melongena L.*).—Five standard varieties were selected for this study. Crosses were made in all twenty possible combinations. The labour involved in making the crosses, the percentage of fruit set for each combination, the number and weight of seed in crossed fruits in each combination, etc. were noted. The hybrid vigour test of all five parents and twelve F_1 progenies, sufficient seedlings of which were available, were conducted in randomised replicated plots. The results are presented in the table below :—

Sl. No.	Parent or Hybrid	Yield in lb./plot	S. No.	Parent or Hybrid	Yield in lb./plot
1.	Pusa Purple Round (P.P.R.)	4·5	10.	P.P.R.X P.P.IL.	7·7
2.	Pusa Purple Long (P.P.L.)	5·2	11.	P.P.R.X W.C.	5·7
3.	Hyderpore (H.)	2·8	12.	P.P.R. XH.	5·4
4.	White clustered (W.C.)	3·8	13.	P.P.R.X W.G.	6·1
5.	Wynad Giant (W.G.)	3·6	14.	W.G. XH.	4·6
6.	P.P.L.X H.	11·3	15.	W.G. X P.P.L.	6·1
7.	P.P.L.X W.G.	9·9	16.	W.G. X H.	4·8
8.	P.P.L.X W.C.	7·9	17.	H. X P.P.L.	7·1
9.	P.P.L.XP.P.R.	8·3			
	SEm				±1·17
	CD at 5%	..	..		2·35

All combinations with P.P.L. as the female parent seems to be very good. The combination P.P.L.X H., which had very attractive fruit characters, gave 113.6 per cent higher yield than the better parent.

16. *Studies on seed production with regard to yield and quality of certain summer and winter vegetables*

Cauliflower (*Brassica oleracea var. botrytis L.*).—A trial was conducted to know the most economic method of producing quality seed of cauliflower. The variety under study was *Pusa Katki*. Four treatments were used for the production of seed. They were (1)

ads left *in situ,* (2) heads transplanted when curds were mature, (3) middle portion of e curd scooped out and heads left *in situ,* (4) middle portion of the curd scooped out and ads transplanted. The seed yield from each treatment is presented in Table 1.

Table 1

Treatment	Yield of seed per pant in gm.	Wt. of 100 seeds in gm
T_1	6·628	0·177
T_2	4·843	0·210
T_3	4·169	0·158
T_4	1·658	0·140

Table 2

Treatment	Yield of seed in oz. (Av. of 10 plants.)
T_1	9·16
T_2	6·49
T_3	8·21
T_4	5·19

The quality of the seeds from each treatment was tested next season in randomised plicated plots. There was no difference in the size of the curd formed from different eatments except that the plants raised from seeds of treatment 1 formed curds 4 to 6 ays earlier than those from other treatments. The plants from all treatments were left *in itu* for seed production. The results are presented in Table 2 above.

The results indicate that cauliflower heads left *in situ* is the best and most economic ethod of seed production.

Radish (*Raphanus sativus L.*).—A trial was conducted to find the most economic ethod of producing quality seed of radish. Four varieties of Asiatic types of radish, were aken for study. Four treatments were used for the production of seed. They were, (1) oots left *in situ,* (2) roots transplanted whole, (3) roots transplanted with $\frac{1}{4}$th cut and (4) oots transplanted with $\frac{1}{2}$ cut. The seed yield from each treatment is presented in the Table .

The quality of the seeds from each treatment for each variety was tested in replicated lots. There was no difference in the performance of the seed from each of the four treatments as is evident from the data presented in the Table 4.

Table 3

Treatment	Yield of seed per plant in gm.			
	V_1	V_2	V_3	V_4
T_1	21·25	..	..	..
T_2	18·50	25·5	3·6	5·5
T_3	12·50	25·5	3·3	4·0
T_4	7·00	20·5	2·6	3·5

Table 4

Treatment	Mean Yield			
	V_1	V_2	V_3	V_4
T_1	11·86	12·9	19·86	12·06
T_2	12·10	12·16	18·80	12·00
T_3	12·00	13·33	15·73	13·80
T_4	10·91	14·30	15·86	15·06
SEm	±0·47	±1·28	±2·13	±1·60
CD at 5%	1·62	4·41	7·34	5·52

7—11 I. .A. R. I/60.

The best and most economic method of radish seed production was found to be keeping the roots *in situ*. In case one is not sure of the purity of seed, he will have to the roots before raising further seed from it. In such cases the best method is to transpla the whole root.

17. *Studies on the chemical induction of male sterility, suppression of male flowers a forcing up of female flowers*

Cucumber (*Cucumis sativus L.*).—This study was initiated in cucumber varie Straight Eight. The object was to modify the sex expression of cucumber by chemic spray and to force more number of female flowers per plant. Four chemicals at differe concentrations as presented in the table below were sprayed on the seedlings. MH-800 pp recorded the highest pollen sterility, which was 60.5%. This effect was, however tempora MH-200 ppm and NAA 100 ppm increased the number of female flowers significantly ov the control. All treatments induced appearance of first female flower on comparative lower nodes of the main axis, when compared with the control. MH-600 and 800 pp NAA-100 and 200 ppm and IAA-100 pmm suppressed the number of male flowers sig ficantly over the control. NAA-100 ppm recorded in the highest female to male flower rati The results have been presented in the table below :—

Sl. No.	Treatment	Av. number of female flowers per plant	Av. number of male flowers per plant	Ratio of female to male flowers
1	Maleic hydrazide 200 ppm . . .	80·66	433·33	1: 5·785
2	,, 400 ppm . . .	53·66	453·00	1: 8·442
3	,, 600 ppm . . .	31·33	300·66	1: 9·596
4	,, 800 ppm . . .	30·33	165·66	1: 5·440
5	alpha-naphthalene acetic acid 100 ppm .	80·33	277·00	1: 3·448
6	,, 200 ppm . . .	61·66	250·67	1: 4·064
7	beta-indoleacetic acid 100 ppm . .	71·66	519·00	1: 7·241
8	,, 200 ppm . . .	59·66	286·67	1: 4·804
9	2, 4-D 5 ppm . . .	69·33	467·00	1: 6·767
10	,, 10 ppm . . .	33·00	411·33	1: 12·46
	Control (no spray)	39·66	597·00	1: 15·05
	SEm	±12·554	±74·191	
	CD at 5%	37·035	218·865	

8. *Studies on the effect of growth regulator spray in destruction or interruption of apical dominance*

Cowpea (*Vigna sinesis* Savi.—A study was conducted on cowpea variety *Pasa Barasati.* The object was to force more side shoots and make the plants bushy by interrupting the apical dominance and to see its effects on the time of maturity and ultimate yield of pods. Two plant regulators, at different concentrations as shown in the table below were used. All the treatments were replicated four times. Apical dominance was interrupted with all concentrations of both MH and SA. The increase in the number of lateral shoots was more pronounced in the case of secondary branches than the primary ones. MH sprays at concentrations between 50 to 200 ppm significantly increased the yield of pod per plant. The maturity of pods was delayed by about a week as a result of the plant regulator sprays. The summary of results are presented in the table below :—

Sl. No.	Treatments	Mean primary branches per plant	Mean secondary branches per plant	Mean pod (mature) yield in oz/plant
1	Maleic hydrazide 50 ppm	4·97	1·51	7·570
2	,, 100 ppm	5·02	1·57	7·520
3	,, 200 ppm	5·09	1·81	7·000
4	,, 400 ppm	5·05	2·13	5·625
5	,, 600 ppm	4·93	2·14	5·617
6	,, 800 ppm	5·64	3·35	5·280
7	Sodium azide 100 ppm	4·91	1·67	6·020
8	,, 200 ppm	4·86	1·63	6·087
9	,, 400 ppm	5·59	2·19	5·790
10	Control (water spray)	4·10	0·55	6·110
	SEm	±0·55	±0·59	±0·195
	CD at 5%	2·465	1·70	0·56

Further studies are in progress.

19. *Studies on the effect of plant regulator sprays on fruit-set.*

Tomato (*Lycopersicon esculentum* Mill.).—Fertilisation in tomato fails when the temperature is too high or too low. This usually is the condition when the first flower clusters appear and as a result they fail to set fruit. The object of this study was to induce fruit set in these first few clusters by some plant regulator sprays. Two sets of trials, flower clusters and whole plant sprays were tried.

Six plant regulators with two concentrations of each were used. There were two checks, one was water spray the other was no spray. Two varieties of tomato Sioux and Pusa Ruby were used. The yield response was found to be related with different plant re- analysed. Total soluble solids in these samples ranged from 65-80% while most and

in the variety Sioux, while indoleacetic acid (IAA) at 100 ppm gave the highest respon in the variety Pusa Ruby. The results are presented in the table below :—

Sl. No.	SIOUX Treatment	Mean yield in lb.	PUSA RUBY Treatments	Mean yield in lb.
1	CIPA 25 ppm	2·08	IAA 100 ppm	2·25
2	NAA 100 ppm	1·85	CPA 25 ppm	1·92
3	Water	1·58	2-4-D 5 ppm	1·75
4	IBA 100 ppm	1·29	NAA 50 ppm	1·72
5	IAA 100 ppm	1·26	IAA 50 ppm	1·66
6	Control (no spray)	1·22	Water	1·59
7	2,4-D 10 ppm	1·21	CPA 50 ppm	1·63
8	IAA 50 ppm	1·20	2,-4-D 50 ppm	1·52
9	2,4-6 5 ppm	1·19	IBA 50 ppm	1·44
10	NAA 50 ppm	1·01	BNA 50 ppm	1·38
11	BNA 100 ppm	1·00	IBA 100 ppm	1·28
12	CLPA 50 ppm	0·98	NAA 100 ppm	1·09
13	IBA 50 ppm	0·86	Control (no spray)	1·09
14	BNA 50 ppm	0·83	BNA 100 ppm	1·04
	SEm	±0·246	SEm	±0·031
	CD at 5%	0·715	CD at 5%	0·064

Fruit Preservation Section

20. *Investigations on Drying of Litchis*

For economical utilisation of surplus litchi fruit during glut season, experiment trials were undertaken to standardize simple techniques of drying this fruit. In all, sixte lots were dried; the details about various experiments are given in the following table :—

Lot No.	Pretreatment	Method of drying	Dried product (Remark
1	Deskinned fruit without sulphitation	In the sun for 35-40 hours	Not satisfactory
2	Do after sulphitation	Do	Do
3	Whole fruit dipped in 2% Potassium meta bi-sulphite (K.M.S.) solution for 24 hours	In the sun for 50-55 hours	Product satisfactory in t beginning but darken rapidly on storage
4	Fruit dipped in 2% K.M.S. solution, dried partially in the sun, deskinned, resulphited in 5% K.M.S. solution for 30 min.	In artificial heat	Product with white colour a good flavour. It contain 900-1000 ppm. So_2 & reconstituted nicely
5	Fruit sulphited & partially dried as above, soaked in equal quantity of water, fumigated with So_2 fumes for 2½ hrs. by burning sulphur@4 lbs. sulphur per ton of fruit	In artificial heat	Product with white colour good flavour It contain 900-1000 ppm. So_2 a reconstituted nicely
6	Steaming & blanching the whole fruit and dipping in K.M.S. solution	In the sun	Good quality product

It was also observed that the absorption of sulphur dioxide from 2% K.M.S. solution aried considerably from fruit to fruit which might be ascribed to the variation in the texure of the skin. There was more leaching of soluble principles from deskinned fruit than om whole fruit during soaking. Drying of the product in artificial heat is further preferable s it is less liable to dust and insect contamination. Further work on the product is in proress.

Drying of Tomatoes.—For successful sun-drying of tomatoes, at least during summer nonths, for use in soup powders, it was observed that scalded fruit after peeling, slicing and hemical treatment dried to an attractive red coloured product when compared with the conol lot. Further work is in progress.

21. *Investigations on Mango Pickle and Chutney*

Preservation of Raw Mango Slices.—Raw mango slices are used in the manufacture of nango chutney which is exported from India in large quantities. The present methods of conserving slices are not very satisfactory and result in their spoilage, loss of colour and texure during storage. Preliminary experiments undertaken for preservation of these slices nave revealed that their pretreatment in 10% brine containing 250 ppm. So_2 and 0.5% acetic icid for 24 hours helps against their spoilage from yeast and mould when subsequently packed in 5% powder salt. The effect of this treatment on the retention of colour and texture of slices is being studied.

22. *Investigations on Fruit Beverages*

Preservation of Phalsa extract and syrup.—Phalsa extract (10% soluble solids and 1.4% acidity as citric acid) prepared by disintegrating 300 gm. fruit with 200 ml. water in a waring blender, heating the blended mass to 80° C, cooling and pressing, was found to be attractive in colour and flavour. It was preserved by treatments like 0.1 and 0.2% sodium propionate and 500, 750 and 1,000 p.p.m. sodium benzoate after addition of 5 and 10% sugar respectively ; after pasteurisation of the unheated and preheated juice for 10 mts. at 85°C. All these treatments resulted in loss of colour and flavour of the extract during a month's storage at room temperature (88°-95°F), sodium benzoate was effective at 0.05% level whereas sodium propionate was not effective even at 0.2% level to keep the extract free from fermentation. Syrups containing 35,45 and 55% sugar retained natural characteristics at 44° F but deteriorated in colour and flavour at room temperature.

23. *Investigations on Indian Preserves (Murrabbas)*

To assess their quality 34 samples of preserves were collected from the industry and analysed. Total soluble solids in these samples ranged from 65-80% while most of them were found fermenting. A few strains of osmophilic yeasts have been isolated from these preserves for use as test organisms in further studies on preserves.

Coordinated Scheme for the Improvement of Watermelon and Muskmelon

The scheme was transferred this year to the Horticulture Division by the Division of Botany. Trials were conducted both at the Jamuna river bed and at I.A.R.I. 14 varieties of watermelon (12 ECs + 2 ICs) were sown in replicated plots. 56 collections of watermelon (46ECs + 10 ICs) were also sown. 6 varieties (2 ECs 4 ICs) in 3 replications and 200 collections of muskmelon (35 ECs and 165 ICs) were sown. The same varietal trials were

also carried out at I.A.R.I. orchard. The number of collection sown at I.A.R.I. were 59 (46 ECs + 13 ICs) of watermelon and 256 (35 ECs + 221 ICs) of muskmelon. All these seeds are carried over from the previous years seed stock with 3 more strains of watermelon from Iran and from Israel and 2 of muksmelon from Iran.

24. *Pure line selection*

Pure lime selection was continued at I.A.R.I. orchard and selfed seeds of all the varieties in replicated trials and 7 collections of watermelon and 24 collections of muskmelon were collected. As the crop was very heavily attacked by fruit fly it was not possible to collect selfed seeds of other collections but open pollinated seeds of all others were collected.

In addition to the varieties recommended last year eleven more collections of muskmelon and nine of watermelon recorded high sugar and flesh and other good fruit qualities.

25. *Preliminary yield trials*

Preliminary yield trials in replicated plots were conducted with promising materials selected in the previous years and their performance has been presented in the table below :

Watermelon			Muskmelon		
Varieties	Av. yield per plant in lbs at Jamuna	Av. Yield per plant in lbs at I.A.R.I.	Varieties	Av. Yield per plant in lbs at Jamuna	Av. Yield per plant in lbs. at I.A.R.I.
New Hampshire Midget	14·80	11·24	Lake Champion	3·23	As the muskmelon crop was heavily affected with fruit flies and as such statistical analysis yield data was not feasible.
Ice box	21·80	6·08	Arbaceshow	1·93	
Rhode Island Red	27·60	13·46	Lucknow type	3·68	
Early Surprise	8·58	21·55	Delhi type local	2·60	
Ashahi Yamato	11·37	15·41	Delhi type Etah	1·87	
Yamato Cream	13·69	10·04	Lucknow type	1·44	
Fuken Mudirigo	18·18	7·06	SEm= ±1·6		
Diamaro Yamato	24·04	8·61	CD at 5% 5·045		
Otome	28·08	9·70			
Kiniku Kahu	9·90	5·50			
Nagaoka Kohai	10·25	12·72	The results were not significant.		
Nagaoka Kohai II	16·26	22·77			
Ambala	14·05	23·26			
Rajasthan	16·10	10·95			
SEm=±2·92		SEm= ±4·06			
CD at 5% 8·505		CD at 5% 11·767			

The yield differences between varieties are significant.

26. *Induction of tetraploidy*

Tetraploidy was induced by colchicine treatment in emulsion in three varieties, two exotic (New Hampshire Midget and Asahi Yamato) and one indigenous variety of watermelon using two concentrations (0.1 and 0.2%) of colchicine. The treated plants were checked morphologically and cytologically for induced tetraploidy. The average percentage of induced tetraploidy was 40 in indigenous variety and 25 in exotic varieties. Appearance of flowers was late in the tetraploid plants. Selfed seeds were collected from the tetraploid plants. One of the crosses with a normal diploid gave some healthy seeds.

Vegetable Breeding Substation, Kulu Valley, Katrain

This sub-station, which was previously under the control of Head of the Division of Botany, has been transferred to the Division of Horticulture since 1/7/1958.

27. *Study of varietal collections of different vegetables.*

A large collection of varieties of different vegetable crops were grown in summer and autumn seasons for evaluation. A small scale replicated trial was laid out with 9 dwarf French bean varieties and Giant Stringless Green Pod as a check. Three varieties, *viz;* Wax podded (EC 1906), Giant Stringless (EC 5843) and EC 8146 out yielded the check. Giant Straingless Green Pod, giving an increased yield of green pods of 54.25, 14.37 and 28.19 per cent over the standard variety. Out of the seven varieties of soybean tested in a small replicated row trial, with IC 547 (Punjab variety) as a check, two varieties; *viz.* EC 2567 and IC 2125 out yielded the check, giving an increased yield of 11.54 and 16.67 per cent respectively, over the standard variety.

Two small scale replicated trials were laid out in peas with 4 dwarf varieties, *viz;* EC 9640, English Wonder, EC 4802, and NP 29 (check) and 3 tall varieties, *viz,* EC 8724 E.C. 9336 and Early Giant (check). The check, N. P. 29 gave the highest yield of green pods (4 lbs 1.4 oz average per row of 18) amongst the dwarf varieties followed by EC 9640 (3 lb 3.3 oz). In case of tall varieties, EC 8724 was the best yielder (3 lbs 6 oz) and the next best was EC 9336 (2 lbs 5.6 oz) as compared to the check, Early Giant (2 lbs 2.5 oz). Though both the varieties outyielded the check, Early Giant, they produced very inferior quality pods.

28. *Evolution of self incompatible and cross-compatible inbred lines.*

The work on the evolution of self-incompatible but cross-compatible inbred lines was continued in cabbage, knolkhol and turnip. In cabbage, 11 inbred lines in strain A, Drum Head and 6 inbred lines in strain, Burpee Drum Head, were tested during the year. In strain A five inbred lines *viz;* A-II, V, VII, VIII and IX were found to be homezygous for self-incompatibility genes while the rest of the inbred lines segregated. None of the inbred lines in strain B was homozygous for self incompatibility genes. Out of the 16 inbred lines of cabbage Golden Acre tested 4 inbred lines, *viz;* II, VII, X and XIV were found to be homozygous for self incompatibility genes. In the knol khol variety White Vienna, out of the 19 inbred lines tested, only two lines, *viz;* A XII and A XIV were found to be homozygous for self incompatibility genes.

29. *Breeding early, midseason and late varieties*

Further selections were made in F_2, F_3 and BC_2 progenies or crosses between th Asiatic and temperate varieties of turnip with a view to improving the roots of the Asiat types. One of the selections, *viz;* PL 11 F of the cross, Japanese White X Snowball show ed an increase of 114.76 and 233.26 percent over the parents Japanese White and Snowba respectively with regard to root size. Similarly few promising selections were made in F and BC_2 progenies of the crosses between Asiatic and Nantes varieties of carrot.

30. *Seed setting and general experiments*

An experiment on spacing of carrot with four spacings *viz;* $2\frac{1}{2}' \times 9''$, $2' \times 2'$, $2\frac{1}{2}' \times 1$ and $2' \times 1\frac{1}{2}'$ and three replications was laid out, the plot size being $12' \times 10'$ (120 sq. ft). Th results of the statistical analysis presented in the table below indicate that the spacing $2\frac{1}{2}' \times 9''$ was the best followed by the spacing, $2' \times 1\frac{1}{2}''$ which was superior to both th remaining spacings of $2' \times 2'$ and $2\frac{1}{2}' \times 1\frac{1}{2}'$ at 5% level.

Spacing	No. of roots required for planting for plot of 120 sq. ft.	Average yield per plot (calculated from 5 plants) in oz.	Calculated yie per acre in lbs
(a) $2\frac{1}{2}' \times 9'$	64	59·00	1338·6
(b) $2' \times 2'$	30	42·33	960·4
(c) $2\frac{1}{2}' \times 1'$	32	41·00	930·2
(d) $2' \times 1\frac{1}{2}'$	40	55·00	1247·8
C.D. at 5%		3·09	70·1
C.D. at 1%		2·38	190·0

31. *Production of nucleus seeds and their multiplication*

Nucleus seeds of 17 varieties of 7 different types of vegetables, *viz.*, cabbage, late caul flower, knol khol, carrot, beet, turnip, and radish were produced.

During the year 1957-58 a total of 5083 lbs of winter and summer vegetable seed were produced as compared to 3290 lbs and 4367 lbs produced during the previous yea 1955-56 and 1956-57 respectively.

26 lbs of seeds of late cauliflower Snowball-16 were produced successfully at the Sub station and the performance of these in trial at the substation and at I.A.R.I. was comparabl to that of the imported seeds.

Programme for work 1959-60

Pomology Section.

1. Survey, collection and evaluation of superior germ plasm in citrus, mango, guav and grapes.
2. Performance of sub-tropical and tropical fruit species and varieties under Delh conditions.

3. Improvement of grapes through hybridization with special reference to earliness, yield and fruit quality.
4. Induction and utilization of polyploidy for the improvement of grapes with special reference to seedlessness and other desirable qualities.
5. Improvement of guava by selection and hybridization with special reference to yield and fruit quality.
6. Improvement of mango by selection and hybridization.
7. Studies on morphology, floral biology and cytology of pomogranate with special reference to problem of sterility.
8. Induction of mutations in citrus through X-rays, fast neutrons and radio-active-isotopes.
9. Studies on the blossom biology and sex-ratio in mango.
10. Taxonomical studies in citrus, mango and other fruit crops.
11. Studies on propagation methods of mango, phalsa, guava and citrus.
12. Standardization of rootstocks in citrus and mango.
13. Plant regulator studies in fruit trees.
14. Survey and collection of garden tools and implements from different states and their improvement.

Vegetable Section

15. Survey and collection of cultivated and wild species and varieties of both indigenous and exotic vegetables and assessment of variability in them and their utilization for breeding.
16. Breeding early, mid-season and late varieties.
17. Studies on sex-ratio in cucurbits.
18. Studies on hybrid vigour.
19. Studies in the inheritance of characters and their linkages in brinjal.
20. Studies on seed production with regard to yield and quality of certain summer and winter vegetables.
21. Studies on the chemical induction of male sterility, suppression of male flowers and forcing up of female flowers.
22. Studies on the effect of growth regulator sprays in destruction or interruption of apical dominance.
23. Studies on the effect of plant regulator sprays on fruit set.

Preservation Section.

24. Survey of Fruit and Vegetable Preservation Industry.
25. Testing different varieties of fruits and vegetables for canning.
26. Investigation on Apple and Amla preserves.
27. Investigation on Sun-drying and Dehydration of fruits and vegetables.
28. Studies on Mango Pickle and Chutney.
29. Studies on fruit Beverages.

18 —1—I.A.R.I./60.

Coordinated scheme for the Improvement of muskmelon and Watermelon

30. Pure line selection work will be continued as far as necessary.
31. Preliminary yield trials will be arranged with promising materials selected during the year 1958-59.
32. Hybridization work will be taken up for combining desirable characters of different lines.
33. Tetraploidy will be induced by colchicine treatment in varieties of watermelons selected on a regional basis. The seeds of triploids will be produced on a larger scale for trial on regional basis.

Vegetable Breeding Sub-station, Katrain

34. Study of varietal collection in different vegetable crops.
35. Evolution of self incompatible and cross-compatible inbred lines, study of their general and specific combining ability and production of hybrid seed in cabbage, turnip and knol khol.
36. Breeding early, mid-season and late varieties of vegetable crops and further improvement of the existing varieties.
37. Seed setting and general experiments.
38. Production of nucleus seeds and their multiplication.

REPORT OF THE DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

(*R. S. Vasudeva*)

A. Section of Plant Pathology

1. *Wheat* (*Triticum aestivum L.*)

(a) *Rusts* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn., *P. triticina* Erikss. and *P. glumarum* (Schmidt.) Erikss. and Henn.]—Four hundred and three field collections of the three rusts, obtained from different parts of the country, were analysed for the study of physiologic races, and races 15, 15-C, 17, 21, 21-A, 21-B, 24, 34, 40, 42 and 42-B of black rust; races 10, 11, 17, 20, 26, 63, 77, 106, 107 and 162 of brown rust; and races 13, 19, 20, 31, A and H of yellow rust were met with. Amongst these, races 40, 21 and 24 of black rust, races 162, 10 and 77 of brown rust, and races 19, 31, 13 and A of yellow rust were mainly prevalent and distributed in the order given above. In the last few years, races 21 and 42-B of black rust were the most predominant ones, but during the year under report race 40 attained the foremost position in its distribution and prevalence. Race 17 of black rust, which had been picked up in the past from Lahaul Valley (Punjab) and Bombay State only, seems to have spread throughout the country. Race 24 also appears to be increasing in prevalence. In the case of brown rust, race 162, which was first isolated from 1955-56 crop, is now most widely distributed.

During the survey of Simla Hills, two grasses, *Bromus* sp. and an unidentified one, were found infected with yellow rust under natural conditions. At Delhi, yellow rust was collected on *Hordeum murinum, H. stenostachys* and *Bromus japonicus;* black rust on *Aegilops bicornis* and *Bromus japonicus;* and brown rust on *Bromus japonicus* and *Bromus* sp. It may, however, be stated that in earlier studies *B. japonicus* had been found to be resistant to a mixture of all the races of brown rust under glasshouse conditions.

In the alternate host studies, seedlings of wheat and *Agropyron* were inoculated under glasshouse conditions with aeciospores collected from *Berberis* spp. in nature, but no infection was obtained in spite of the fact that aeciospores showed 10-20% germination. In another experiment, aeciospores from *Aecidium montanum*, showing 5-20% viability, were put on seedlings of *Poa nemoralis* and *P. annua,* but no infection occurred. Selfing studies with races 21 and 42 of *Puccinia graminis tritici* were continued and both the races were found to be heterozygous.

In the seedling resistance tests, about 18,000 plants of wheat varieties, crosses and their progenies in different generations were tested against individual races of the three rusts or their mixtures. Wheat varieties E. 2025 and H-25 Sel. 1 were found to be resistant to all the individual races of brown rust; selections H 546-2 Pl. 1-5, H 546-2 Pl. 1-14, H 546-2 Pl. 4-85, H 546-2 Pl. 13-260, H 546-2 Pl. 13-263, H 547-2 Pl. 2-11, H 264-5 Pl. 1-4-2-3, E. 4248, I-133/1 and I-133/2 to a mixture of races of black rust; H 546-2 Pl. 15-279, H 545-2 Pl. 8-58 and H 547-2 Pl. 2-11 to a mixture of races of brown rust; and H 546-2 Pl. 4-70, H 546-2 Pl. 5-130, H 546-2 Pl. 10-222, H 546-2 Pl. 12-249, H 546-2 Pl. 13-260, Eritrospermum IZR-142, Eritrospermum IZR-953, Eritrospermum IZR-983 H(P) 57-287, AE 17-1, AE 27-1, AE 49-1, AE 66-3, AE 66-5, AE 154-2, AE 193-3, AE 270-2, AE 295-3, AE 400-1, AE 408-3, AE 423-4,

AE 547-1 and AE 573-1 to a mixture of races of yellow rust. Wheat variety E. 3123 (Kenya-A.J. 4-A-1), which was reported last year to be resistant to all the races of black rust individually in the seedling stage under glasshouse conditions, became susceptible to races 15, 15-C, 34, 40, 122 and 194 at higher temperature (18-34° C.). At lower temperature (6-16°C.), however, it remained resistant to all the races.

A large number of wheat varieties, crosses, fixed hybrids and other material were tested in the adult stage for their resistance to the three rusts of wheat by creating artificial epidemics in the field. An area of about 5 acres was inoculated with a mixture of all the races (except race 122 of black rust) of the three rusts and good infection was obtained. Observations were taken on about 150,000 single plants and promising material was selected in collaboration with the Division of Botany.

Studies on the survival of black rust races in mixture were continued and a combination of races 15 and 21 was maintained for 8 generations on wheat varieties NP 4, NP 710, NP 718, Pb. C. 591 and *Agra local*. The relative proportion of the two races was determined at the end of each generation. In the eighth generation, the ratio of races 15 and 21 on varieties NP 4, NP 710, NP 718, Pb. C. 591 and *Agra local* was 3.2: 96.8, 95.7: 4.3, 4.2: 95.8, 71.1: 28.9 and 65.1: 34.9, respectively. Thus, from the experimental data so far obtained it appears that the frequency of a race in a mixture is determined mainly by the variety on which the mixture is maintained.

(b) *Loose Smut* [*Ustilago tritici* (Pers.) *Rostr.*].—Of the 60 wheat varieties tested for their resistance to the disease at Delhi under field conditions, 30 remained free from smut infection. Amongst the smut-free varieties, NP 822, NP 823, NP 824, NP 825, NP 826, E. 381, E. 3319, HD (52)-34, HD (52)-60, HD (53)-103 and HD (53)-110 have consistently remained free from infection during the last three years' tests. Infection obtained in the susceptible varieties, used as control, was as high as 90-97%.

In order to further select resistant substrains within the highly susceptible wheat variety NP 775, which otherwise shows good agronomical characters, four, out of 36 single-plant selections, and one, out of 5 bulked selections, showing complete freedom from smut, were re-inoculated, while the remaining were rejected as they showed more than 10% infection.

Further studies on the hybridization of NP 775 with the smut-resistant varieties, NP 790 and NP 798, with a view to introduce loose smut resistance in NP 775 were continued in collaboration with the Division of Botany. In this connection, 102 promising plants of 39 B3 selfed-1 families of two crosses (NP 775 x NP 790 and NP 775 x NP 798) and their reciprocals, showing less than 10% smut infection, as also 142 plants of 38 B3 selfed-1 families of the above crosses were inoculated with the pathogen.

Work on the selection of suitable differentials for the study of physiologic races within the pathogen was in progress and, in this connection, 9 wheat varieties were inoculated with 10 different isolates of the pathogen.

(c) *Karnal Bunt* [*Neovossia indica* (Mitra) Mundkur] and *Hill Bunt* [*Tilletia caries* (DC.) Tul. and *T. foetida* (Wallr.) Liro].—Out of 165 wheat varieties tested for their resistance to Karnal Bunt under field conditions at Karnal and in pots at Delhi with the sporidial suspension of *Neovossia indica* by the hypodermic syringe method in boot-leaf stage, 148 varieties remained free from infection. The maximum infection obtained in the susceptible varieties was 24.5% on ear basis. As in the last year, this low percentage of

infection was due to unfavourable weather conditions at the time of inoculation. Even improvised arrangements of higher temperature and humidity in the field during the cold months of December and January for the inoculated plants failed to give any better infection. In the studies on the physiology of the pathogen, Richards' medium plus yeast extract at pH 5.5 supported maximum growth and sporulation. Of the various concentrations of yeast extract tried, 0.1% was found to be the optimum dose. Furthermore, Sucrose was found to be a better source of carbon than Dextrose, Maltose, Lactose and Galactose for growth and sporulation of the bunt organism.

In the varietal resistance tests against Hill Bunt (*Tilletia foetida*) at Simla with 100 wheat varieties, 21 varieties (E. 189, E. 2329, E. 2469, E. 2959, E. 3207, E. 3210, E. 3213, E. 3217, E. 3459, E. 4415, E. 4416, E. 2519, E. 2589, E. 2965, E. 3205, E. 3142, E. 3212, E. 3214, E. 3215, E. 3216 and E. 4433) reacted as resistant. Eleven wheat varieties (E. 192, E. 197, E. 201, E. 2327, E. 2469, E. 2961, E. 2965, E. 2974, E. 3214, WB 94 and Australian No. 1), found promising against *T. foetida* in the last year's trial, were tested again with *T. caries* and all of them proved to be resistant. For physiologic race study, 37 bunt samples (26 of *T. foetida* and 11 of *T. caries*) were analysed and indications of 8 races of *T. foetida,* and 7 of *T. caries* were obtained. In host-range studies, 10 varieties of barley and 2 of rye as also 15 different grasses were tested against *T. foetida,* but only 4 species of *Aegilops* (*A. cylindrica, A. longissima, A. squarrosa* and *A. ventricosa*) and Lyallpur rye got infected. Furthermore, it was confirmed that bunt chlamydospores lost their viability within one season when the bunted ears, kept on the surface or buried in the soil, were exposed to natural conditions after harvest, while those kept inside the laboratory at room temperature remained viable for more than 3 years. Artificially infected seed, exposed to temperatures ranging from 25° to 65 °C. for 24 hours, showed that some of the spores retained their viability even at 50°C. but seed germination was greatly impaired. It was further observed that infection progressively increased with increase in depth of sowing as also with increase in sporeload used as inoculum. In the studies on the possibility of screening varieties in seedling stage, it was observed that the bunt mycelium was traceable both in susceptible and resistant varieties in 10-15 days old wheat seedlings, while it could be detected only in the susceptible varieties in 35-75 days old seedlings.

(d) *Powdery mildew* [*Erysiphe graminis tritici* EL. Marchal].—Germination of conidia, collected from the infected plants at different times of the day, showed that conidia formed under high humidity germinated better than those formed at low humidity. However, conidia failed to germinate when collected from the infected plants kept at 8% relative humidity and 25 °C. It was further found that there was a marked increase in respiration in heavily infected leaves as compared to healthy leaves.

2. *Barley* (*Hordeum vulgare* L.)

(a) *Rusts* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn., *P. glumarum* (Schmidt.) Erikss. and Henn. and *P. hordei* Otth.].—Thirty-three samples of black and yellow rusts, collected from different parts of the country, were analysed and races 17, 21, 21-A, 21-B, 34 and 40 of black rust and races 19, 31 and G of yellow rust were met with. In the seedling resistance tests, barley varieties BH 4-4-A/58, BH 4-4-B/58, BH 36A-3-A/56 and BH 37-3C/58 were found to be resistant to a mixture of races of yellow rust. None of the varieties, tested against the individual races of black rust or their mixture, was, however, found to be resistant.

Leaf rust of barley (*Puccinia hordei*) was again observed this year in the experimental plots at I.A.R.I., but incidence of the rust was very mild. Nine samples of the rust, collected from the last year's crop, were analysed and races H1 and H2 were encountered.

(b) '*Molya*' *disease*.—Diseased barley and wheat plants, collected from Rajasthan, yielded a large number of cysts of *Heterodera* sp. as also species of *Fusarium* and *Helminthosporium* from roots. Analysis of soil samples from diseased fields also showed the presence of a heavy population of larvae of *Heterodera* sp. Pathogenicity tests are in progress with the nematode and the two fungi, singly and in different combinations, to determine their role in the development of the disease.

3. *Bajra* (*Pennisetum typhoides* Stapf and Hubbard)

Green-ear disease [*Sclerospora graminicola* (Sacc.) Schroet].—Oospore material, collected from Delhi and Jodhpur, was tested for germination. Maximum germination (20%) was obtained when the material was buried in the field for weathering. Effect of some organic acids (lactic, malic and succinic acids) on the germination of oospores was also tried, but none of the treatments accelerated oospore germination.

In the varietal resistance tests with 20 *bajra* varieties, 3 varieties (I.C. 1518, I.C. 1718 and I.C. 4377) remained free from infection under field conditions. The highest infection obtained in these tests was 20%.

4. *Jowar* (*Sorghum vulgare* Pers.)

Grain smut [*Sphacelotheca sorghi* (Link) Clint.].—In the varietal resistance tests with 24 *jowar* varieties, 8 (P.J. 1.K., P.J. 3. K., P.J. 7. K., P.J. 23. K., P.J. 24. K., S.E.S., Bilichigan and Nandyal) remained free from infection. Maximum infection obtained in some of the susceptible varieties was as high as 70%.

5. *Sugarcane* (*Saccharum officinarum* L.)

(a) *Red Rot* [*Colletotrichum falcatum* Went].—During the year under report, Red Rot affected areas of Eastern and Central Uttar Pradesh were surveyed and a large number of diseased samples were collected from these localities. Cane variety Co. 453 was found affected with Red Rot at all the places visited in Eastern U.P. Besides Co. 453, cane varieties Co. 312, Co. 331, Co. 393, Co. 419, Co. 421, B.O. 11, Co. S. 245, Co. S. 321, Co. S. 443 and Co. S. 510 also showed Red Rot infection in traces. Red Rot in the form of a localised epidemic was also reported from a few villages of the Punjab near Bahadurgarh where cane variety Co. 312 showed infection. Most of the isolates obtained from these samples were of light type. These are being maintained for further study.

In the varietal resistance tests, 186 important and promising cane varieties, including some commercially important ones from different cane tracts of India, were tested by the Standard Plug method with *C. falcatum* isolate No. 244. Two varieties, Co. 1148 and Co. 1159, were found to be resistant; 162 reacted as moderately resistant; and the remaining 22 reacted as susceptible. Likewise, 97 cane varieties were tested for their nodal resistance to Red Rot. One variety, Co. 1080, reacted as resistant; 3 behaved as moderately resistant; 14 as susceptible; and 79 as highly susceptible. Four varieties, *i.e.*, Co. 299, Co. 1056, Co. 1221 and Co. 1224 showed 100% infection and several of the inoculated canes developed advanced infection and had dried up. In the experiment for retesting of varieties resistant to isolate No. 244 with various virulent *C. falcatum* isolates from important cane tracts of the country, 9 varieties reacted as moderately resistant, while the remaining 3 proved susceptible.

The performance of 30 *C. falcatum* isolates (4 dark and 26 light type) was studied regarding their virulence on the ten standard cane varieties. Of the isolates tested, No. 374, a light and profusely sporing type isolate (from Co. 453, Uttar Pradesh), was found to be most virulent on cane varieties Co. 213, Co. 299, Co. 313 and Co. 356. Isolate No. 375 (from Co. 312, Uttar Pradesh) also gave fairly high infection. However, the light type isolates, in general, gave higher infection than the dark types in most of the cane varieties tested. Strains D and I of the pathogen from Bihar proved less virulent than isolate No. 244. Strain D was, however, more virulent than strain I.

In the experiment to determine the effect of mixed inocula on Red Rot infection, 7 combinations of various light and dark types, light and light types, and dark and dark types of *C. falcatum* isolates were tried on the ten standard cane varieties. It was observed that 7 varieties of the ten tested gave greater infection when inoculated with a mixture of isolates No. 390 (light) and 78 (dark) than with either of the individual isolates. It was further seen that all the varieties showed more infection when inoculated with a mixture of dark (No. 78) and light (No. 390) type isolates as compared to the infection obtained with two light types (Nos. 390 and 359) or two dark types (Nos. 78 and 334).

Reisolations made from 118 cane varieties, inoculated with a light type *C. falcatum* (isolate No. 244), indicated that the passage through certain cane varieties tended to change the light type isolate into dark type. This is being further investigated and the effect of repeated passage through these cane varieties as also leaves of sugarcane and other related plant species is being studied. Furthermore, a large number of Red Rot affected cane stalks and leaves of different varieties from different localities in Punjab, U.P. and Madras States were collected and the isolations made for the causal organism. Twenty-nine selected isolates, on examination, showed a range of 25-38 microns in the length of conidia.

(b) *Smut* [*Ustilago scitaminea* Syd.].—In the varietal resistance tests, 86 cane varieties at Karnal and 75 at Delhi were tested for their resistance to smut. At Karnal, 28 varieties gave less than 5% infection, 12 showed 5-15% infection, 25 gave 15-30% infection and in the remaining 21 varieties the infection ranged from 30-100%. However, in 14 varieties, where the infection was less than 5%, the number of clumps on which the observations were based was less than ten. The corresponding figures for the experiment at Delhi were 3, 1, 4 and 67. The 17 varieties (14 at Karnal and 3 at Delhi), which gave less than 5% infection, may be considered as resistant. These are Co. 356, Co. 445, Co. 1006, Co. 1017, Co. 1030, Co. 1110, Co. 1122, Co. 1123, Co. 1135, Co. 1167, Co. 1170, Co. 1225, Co. 1230, Co. 1231, Co. S. 515, B. O. 28 and B. O. 30. Six of the above varieties, namely, Co. 356, Co. 445, Co. 1006, Co. 1170, Co. S. 515 and B. O. 28, had proved resistant in the previous years' tests also.

(c) *Rust* [*Puccinia kuehnii* (Krueger) Butler].—Six cultures of the rust have been established and are being maintained at the Simla Substation. Technique for maintaining these cultures under Delhi conditions is being worked out. One culture has been successfully maintained at Delhi through the hot summer months. Rust collections are being made from different parts of the country and different cane varieties for further study.

6. *Linseed* (*Linum usitatissimum* L.)

(a) *Rust* [*Melampsora lini* (Pers.) Lev.].—One hundred and one samples of the rust, collected from different parts of the country, were analysed and all the five Indian races of *Melampsora lini* were encountered. No new race was, however, isolated. Of the 599 linseed varieties tested in the adult stage under field conditions, 486 proved to be resistant.

(b) *Wilt* [*Fusarium oxysporum* Schl. f. *lini* (Bolley) Snyder and Hansen].—Studies on linseed wilt were initiated with 10 cultures of the pathogen isolated from wilted plants which were collected from different parts of the country. Sixteen linseed varieties were tested for their resistance to the disease in the wilt-sick plot (inoculated with a mixture of the ten isolates) and two varieties, namely, NP (RR) 9 and B 5128, showed a fair degree of resistance. Cultural studies showed some variation among different isolates.

7. *Pigeonpea* [*Cajanus cajan* (L.) Millsp.]

Wilt [*Fusarium udum* Butler].—Of the 20 pigeonpea varieties tested for resistance to the disease, two varieties, namely, N.P. (W.R.) 15 and S. 37, in pots and three varieties, namely, N.P. (W.R.) 15, S. 37 and S. 79, in the field did not develop any wilt symptoms

8. *Antibiosis*

Studies on the antibiotic, Bulbiformin, from *Bacillus subtilis* were continued. Bacterisation of pigeonpea seed with *B. subtilis* showed that appreciable amount of the antibiotic was produced on the seed-coat and cotyledons which helped in the reduction of wilt incidence. The antibiotic production on seed-coat was, however, considerably enhanced when the seed bacterisation was effected with the bacterial suspension in molasses and groundnut-cake. Furthermore, it was found that the antibiotic production was more in the exudate of cotyledons than that of seed-coat or entire seed. Fairly good amount of the antibiotic activity was also detected in soil in the vicinity of the bacterised seed. Finally, it was observed that the antibiotic produced on seed-coat was systemic and was translocated to the roots, stems and leaves of seedlings.

9. *Physiology of fungi*

Work on the physiology of light and dark type isolates of *Colletotrichum falcatum*, the causal organism of Red Rot of sugarcane, showed that the dark type isolate No. 78 required biotin for its growth, but the addition of the vitamin did not increase its virulence. However, an advance dose of nitrogenous compounds, both organic and inorganic (except nitrites), significantly increased its linear spread of infection in the two cane varieties, Co. 312 and Co. 647, tested. In cultural studies, it was found that pectolytic activity of the filtrate and reduction of sucrose were comparatively greater with the light type of isolate than with the dark type. It was further observed that addition of pectin increased both the pectolytic activity and pH of the medium in case of the former, while it slightly reduced pH in case of the latter without affecting lipolytic activity.

Studies on the factors affecting the production of perithecia of *C. falcatum* were continued. Perithecia were obtained on dry autoclaved leaves of sugarcane at 25°C. when kept in light and in direct contact with water at pH 7. Even 100% relative humidity did not induce perithecial formation. Mature perthecia were also produced on autoclaved leaves of *Erianthus munja, Pennisetum typhoides, Sorghum vulgare* and *Bambusa* sp. as also on the chlorophyll extracted green leaves of maize and sugarcane. The intensity of perithecial formation was found to vary considerably on the leaves of different cane varieties, the maximum being on Co. 421, Co. 661 and Co. 1006 and none on Co. 840. It was further observed that the pathogen lost the capacity to form perithecia when it was maintained on artificial media for a long time.

The mutant strain of *Macrophoma mangiferae*, the causal organism of blight disease n mango, produced perithecia on mango-leaf decoction agar at 25-30°C. in 7-10 days. The utant was found to be homothallic in nature as perithecia were formed with a single cospore culture.

In tissue-culture studies, callus tissues of mosaic affected and healthy plants of sann- mp were successfully maintained on White's medium for 5 generations.

). *Effect of atomic Radiations on Micro-organisms*

Further studies on the biochemical mutant of *Colletotrichum falcatum*, deficient in -aminobenzoic acid (PABA) obtained through irradiation in growth phase with 243 micro- aries per ml. of P^{32}, were continued. It was observed that the relative germination of onidia of the mutant strain was much less than that of the parent culture on different sub- rata tried (including PABA). Studies on its vitamin requirement showed that there was linear correlation between the concentration of PABA and growth within the range of 001 to 0.01 micrograms per ml. of the vitamin, indicating thereby that the mutant can be sed for microbiological assay of the vitamin. Higher concentrations, on the other hand, epressed growth of the mutant. It was further found that the mutant had completely lost s pathogenicity, which could be partially restored by incorporating a small quantity of the itamin in the inoculum. Utilizing the phenomenon of competitive antagonism between ulphanilamide and PABA, it was observed that the parent culture synthesized PABA in xcess of its requirement.

Work on the biochemical mutant of *C. falcatum*, deficient in biotin, also showed that here was a progressive increase in its growth when there was change in the concentration f biotin from 0.0001 to 0.002 micrograms per ml., indicating thereby that this mutant can lso be used for micro-biological assay. There was, however, no appreciable increase in its irulence when the vitamin was incorporated in the inoculum which showed that biotin was vailable to the mutant from the cane juice.

It was observed that thermal neutrons with a flux of 2.1×10^7 ns./cm²/sec. up to hours did not seem to have any significant effect on the conidial germination of *C. alcatum*. Moreover, the treatment did not induce any visible mutation in *C. falcatum* or howed any differential effect on *Ustilago nuda* and its host.

1. *Fungicides*

The fungitoxicity of Mycobacillin, an antibiotic produced by *Bacillus subtilis*, was ompared with Parzate liquid (disodium ethylenebis dithiocarbamate) plus zinc sulphate n the laboratory against the spores of *Puccinia graminis tritici* and the latter was found to e ten times more toxic than the former. Mercury acetate, Tolylmercury chloride, 10% mulsifiable thiocyanoacetate of glycerol and 20% emulsifiable thiocyanoacetate of geraniol, ent by the Organic Chemist (I.A.R.I.), were also screened for their fungicidal properties with *Alternaria tenuis* as test organism, and they were found to inhibit the germination of 95% pores at 1 ppm., 1 ppm., 1000 ppm. and 10000 ppm., respectively.

A laboratory experiment to test the comparative efficacy of 22 proprietary fungicides or the control of damping off' (*Pythium debaryanum*) of chillies was repeated. It was bserved that pre-and post-emergence "damping off" was reduced to 12.2% and 7.7%, respec- vely, when seeds were treated with Flit 406 (n-(trichloromethylmercapto)-4-cyclohexene-1, -dicarboximide) as against 54.8% and 42.9% in the untreated controls.

Comparative field fungicidal trial with 9 fungicides for the control of black rust o wheat showed that four sprayings with Parzate liquid plus zinc sulphate, at an interval o 15 days from the first week of February onwards, reduced the intensity of black rust infe tion from 40-65% in the control to 0-2% in the sprayed plots. This resulted in an increase o 69.7% in yield over the control.

In a comparative seed-dressing fungicidal trial for the control of stem rot of ju (*Macrophomina phaseoli*), all the 9 fungicides tried showed beneficial effect in increasin germination. Flit 406, however, gave the best results and reduced infection to 9.1% a against 58.8% in the control. In another experiment for the control of covered smut o barley (*Ustilago hordei*) with 19 fungicides, Ceresan M (N-(ethylmercury)-p-toluenesu phonanilide) and Agrosan 5W (organically combined mercury) reduced the smut infectio to 0.4% and 0%, respectively, as against 8.4% in the control. Field experiments for th control of stripe disease of barley (*Helminthosporium gramineum*) by seed treatment and o fruit rot of chillies (*Colletotrichum capsici*) by spraying were also in progress.

12. *Seed Testing and Plant Introduction*

Seeds of 10 common vegetables, *i.e.*, cabbage, radish, *tinda*, French-bean, peas, *gua* onion, *bhindi, brinjal* and chilli, collected from different localities, were tested for seed-born fungal flora and about 45 isolates, belonging to 12 genera (*Alternaria, Aspergillus, Cha tomium, Colletotrichum, Rhizoctonia, Curvularia, Fusarium, Gloeosporium, Penicillium Rhizopus, Phomopsis* and *Stemphylium*), were obtained. In addition, 66 seed samples o imported wheat were examined for ecto and endo-phytic fungal flora. None of the sample yielded any internally seed-borne pathogen, but they were externally contaminated wit species of common saprophytic fungi like *Rhizopus, Mucor, Aspergillus, Curvularia* an *Alternaria,* either singly or in different combinations.

About 1500 seed samples and living material of different crops, received from foreig countries or intended for export, were examined for ectophytic fungal flora and suitabl treated with fungicides for surface disinfection. Phytosanitary certificates were issued whe ever warranted. About 250 samples had to be rejected as these were found infested wit pathogenic organisms.

13. *Assessment of Losses due to Plant Diseases*

Studies on the assessment of losses due to some important diseases of plants wer continued.

The first year yield from 300 bushes of cardamom, affected with 'Katte' disease, wa found to be 7.3 lbs. as against 12.9 lbs. from the same number of healthy bushes. Th score-card evolved last year for appraising losses due to groundnut mosaic was again teste this year and was found to work satisfactorily. The losses in yield for 0%, 1-25%, 26-50% 51-75% and 76-100% infection-categories in the crop sown on 11-6-58 were 0%, 34.5%, 73.2% 89.2% and 97.2%, respectively, while in the crop sown on 15-7-58 they were 0%, 37.3% 62.3%, 72.9% and 85.5%.

Losses due to linseed rust were found to be 86% and 66% for susceptible (NP 21 and semi-resistant (NP 12) varieties, respectively, when the disease incidence ranged fro 90 to 100%. Losses were observed to be greater in the late-sown crop (22-11-58) and wer inversely proportional to the age of plants when the infection took place. In the case o stem rot (*Macrophomina phaseoli*) of sesamum, the losses obsewed for 10%, 25%, 50%

75% and 100% infection-categories were 9%, 25%, 30%, 61% and 70%, respectively. The various disease-categories were based on the stem area involved. For studying losses caused by powdery mildew (*Erysiphe polygoni*) of peas, which appears in a serious form almost every year, the various disease intensity/loss coefficients were worked out. Pod weight appeared to be a better index number than pod number or gross weight of green plants. The losses were calculated to be 0%, 9.3%, 21.1%, 37.5% and 40.8% with 0%, 1-25%, 26-50%, 51-75% and 76-100% infection, respectively. Different disease-categories were obtained by dusting the plants with finely powdered sulphur. Preliminary observations on leaf blight of maize (*Trichometasphaeria turcica*) in the Simla Hills showed that Ulstrup's diagrammatic scale for measurement of disease intensity was quite useful.

Angular leaf spot (*Xanthomonas malvacearum*) of cotton is known to cause serious defoliation in the affected crop which results in heavy loss in yield. A field experiment was, therefore, laid out to study the effect of artificial defoliation on loss in yield and the losses were estimated to be 6%, 26%, 63% and 100% with 25%, 50%, 75% and 100% defoliation, respectively.

14. *Miscellaneous*

(a) *Cercospora leaf spot of grapes.*—Diseased specimens were collected from different parts of the country and *Cercospora viticola* (Ces.) Sacc., known to be causal agent of this disease in India, as also another species of *Cercospora,* close to *C. riachueli* Speg., were isolated. Detailed cultural, physiological and pathological studies were, however made with *C. viticola* only.

(b) *Safflower rust* (*Puccinia carthami* Corda).—Heterothallic nature of the fungus was confirmed. Diplodization was brought about either by cell fusion (Christman type) or by the fusion of pycniospores with the flexuous hyphae. In monosporidial cultures, "uredinoid" aeciospores appeared rarely and they were found to be incapable of infecting safflower. In histo-pathological studies, "Internal Sporulation" in the cortex of stem was observed.

(c) *Powdery mildew of tobacco* (*Erysiphe cichoracearum* DC.).—Conidia produced at 22-25°C. and 55-70% relative humidity as well as those collected in the early hours of the day gave maximum germination. Optimum conditions for conidial germination were found to be 22-25°C. and pH 8-0.

(d) *"Die-back" or roses* (*Diplodia* sp.).—The disease was found to be due to a species of *Diplodia* and was effectively controlled by the application of improved "Chaubatia" paste on the pruned surfaces immediately after pruning.

(e) *Nematodes in relation to plant diseases.*—A serious disease of sugarcane, associated with nematodes (*Tylenchorhynchus* sp.) in a few localised fields in Nellikuppam, (S. Arcot, Madras) area was observed affecting cane varieties Co. 449, Co. 1001 and H. 32/8560. A number of vegetable crops (including tomato, *brinjal* and *bhindi*) in the Institute Farm were found to be severely infested with root-knot nematodes (*Meloidogyne* spp.). Cultures of these nematodes have been established for further studies.

B. Section of Plant Bacteriology

15. *"Tundu" (Yellow ear rot) disease of wheat* (*Corynebacterium tritici* (Hutchinson) Bergey *et al.*)

Studies on the relationship between *Corynebacterium tritici* and *Anguina tritici* (Earcockle nematode) in the development of "Tundu" disease of wheat were continued. Presence

of the bacterium (*C. tritici*) in the growing-points of the infected wheat seedlings was agai shown both by isolation and histological techniques, but its presence in nematode galls however, could not be demonstrated.

16. *Citrus Canker* (*Xanthomonas citri* (Hasse) Dowson)

Further studies on the factors affecting the rapid decline of *Xanthomonas citri* in soi were continued. It was found that the pathogen survived for 52 days in all the three type of soil tried (black cotton, alluvial and sandy with pH around 7). Furthermore, the orga nism was found to survive for 150 days at soil temperature of 5-15C, for 52 days at 30C and was killed at 40°C. In saturated and moist soils, the pathogen survived for 52 days, bu in dry soil its viability was limited to 37 days only. Soil reaction also showed marked effec on the survival of *X. citri* in soil as it declined within 3 days at pH 5.7 and within 5 day at pH 9.0, but remained viable for 52 days at pH 7.0.

In order to determine the antagonistic effect of soil microflora on the survival of th pathogen, only 3, out of 52 actinomycetes isolated, 2 belonging to the genus *Streptomyce* and one to *Micromonospora,* showed inhibitory effect on *X. citri.* These organisms hav been tentatively identified as *Streptomyces antibioticus* Waksman and Woodruff, *S. griseu* Krainsky and *Micromonospora fusca* Jensen.

17. *Bacterial Leaf Spot of chilli* (*Xanthomonas vesicatoria* (Doidge) Dowson)

Host-range studies and varietal resistance tests were in progress. Forty-one chill varieties were tested for their resistance to the disease, of which 2(Kondiveram and G) pro ved to be resistant. Furthemore, 16 plant species were inoculated with the pathogen fo determining its host-range, but only *Capsicum pendulum* and *C. microcarpum* got infected

18. *Bacterial Stalk and Ear-Rot of Maize* (*Erwinia carotovora* f. sp. *zeae* Sabet)

During the year 1957-58, maize plants growing in the Institute Farm showed eithe rotting of the basal portion of the stalk or of ear and ear-shank. The leaves and ear cover were also infected. Subsequently, the disease was found to be fairly prevalent in othe maize-growing areas of the country. It was extremely destructive to some of the potentially important exotic varieties of maize. A few of the "Indigenous" varieties also showed infec tion.

Isolations from the diseased plants consistently yielded a bacterium, pathogenicity o which was established. The causal organism has been identified as *Erwinia carotovora* f. sp *zeae.*

19. *Bacteriophages*

Studies on the role of bacteriophages in the identification, survival and control o *Xanthomonas citri,* were initiated. Properties of the phage, isolated last year from diseased leaves of *Citrus paradisi* (grape fruit), were further studied. The phage had a maximum titre of 10^{-9}, having 7×10^{9} phage particles per ml. of the stock phage. It was inactivated by a 10 minute exposure at 75C and by chloroform treatment when 0.5 ml. of the chemical was added to 5 ml. of the stock phage. Phages were also isolated from diseased leaves of *C aurantifolia* and from soil samples collected from underneath the diseased citrus trees. The two appear to be either different phages or different strains of the same phage, as judged by plaque morphology and size of phage particles. Further work in this connection is in progress.

The presence of phages in the waters of river Ganges, collected at Hardwar and Allahabad, was also observed, using *Escherichia coli* as a test organism.

20. *Bhindi* (*Abelmoschus esculentus* Moench.)

Yellow-vein mosaic.—In the varietal resistance tests, the interspecific cross, *Abelmoschus manihot* var. *pungens* *A. esculentus,* showed tolerant reaction. The *bhindi* varieties Best I and Kitchen Garden selection as well as 5 crosses with Best I and one with Best II were successfully infected with the virus, but only mild symptoms were produced.

21. *Chilli* (*Capsicum frutescens* L.)

(a) *Mosaic.*—Six crosses between the chilli varieties Puri Red and N.P. 46-A and two between Puri Red and N.P. 41 proved to be resistant to the disease. Twenty-one chilli varieties were tested for their resistance to the disease and all proved to be susceptible.

22. *Brinjal* (*Solanum melongena* L.)

Mosaic.—Nine more collections of *brinjal* mosaic from different localities in Poona were analysed for the presence of the viruses involved and, in addition to the four viruses previously reported, one more was isolated. This virus appears to be a new record on *brinjal.* In the insect transmission tests, the strain of cucumber mosaic virus, producing mosaic symptoms in *brinjal,* was transmitted to *brinjal* and cucumber more efficiently by *Aphis malvae* than by *Aphis gossypii.*

23. *Sesamum* (*Sesamum orientale.*)

Phyllody.—The virus was successfully transmitted to *Crotalaria orixensis, Vigna sinensis, Melilotus alba, Trifolium repens, T. incarnatum, T. cernuum, Medicago lupulina, Tropaeolum majus, Antirrhinum majus, Calendula officinalis, Parthenium* sp. and *Stachytarpheta indica,* through viruliferous jassids (*Deltocephalus* sp.). In the varietal resistance tests, all the eight varieties and ten selections of sesamum tested were found to be susceptible to the disease when tested by grafting or through viruliferous jassids.

24. *Sugarcane* (*Saccharum officinarum* L.)

(a) *Mosaic.*—Maize plants were successfully infected by juice inoculation with the severe type of mosaic virus obtained from the cane variety Co. 527 when the juice was extracted in 0.5% sodium sulphite and centrifuged for 10 minutes at 3000 r.p.m. Preliminary tests have indicated that the thermal-death-point of the virus lies at about 45° C.

(b) *"Grassy-shoot".*—In the host-range studies, the virus was successfully transmitted to *Pennisetum ciliaris* (Madras grass) through the vector (*Longiunguis sacchari*), while maize was found to be a symptomless carrier. The virus was also transmitted from sugarcane to *jowar* through *Aphis maidis.*

25. *Sannhemp* (*Crotalaria juncea* L.)

Studies on the effect of host plant nutrition on the growth of sannhemp plants as well as on the multiplication and concentration of sannhemp mosaic virus were initiated. Nitrogen level of 1050 ppm. was found to be optimum for the growth of sannhemp plants, as judged by their height, weight of green tissue and dry weight. In the experiments conducted to study the effect of different levels of nitrogen nutrition (0, 21, 70, 210, 420, 630, 1050, 1330 and 2100 ppm.) on the concentration of sannhemp mosaic virus in the inoculated sannhemp plants, it was observed that the virus concentration was directly correlated with the vegetative growth of plants at different nitrogen levels. Concentration of the virus progressively

increased with the increase in nitrogen level up to 1050 ppm., while there was a sudden drop in the virus concentration at nitrogen levels of 1330 and 2100 ppm. with a corresponding retardation in the growth of the host plant.

26. *Chinese Sarson* (*Brassica juncea* Czern. and Coss. var. *rugosa* Roxb.)

Mosaic.—*Aphis rumicis* was found to be an additional vector of the virus. Nymphs and apterous adults of *Brevicoryne brassicae* were found to be more efficient in transmitting the virus than the alate forms.

27. *Broad-Bean* (*Vicia faba* L.)

Mosaic.—The virus was found to be present in different parts of flowers of the infected plants, except pollen grains. In the host-range studies, the virus was successfully transmitted to sannhemp and soybean, while gram was found to be a symptomless carrier. The optimum pH range for the infection of broad-bean plants was found to be 8 to 10. *Macrosiphoniella sanborni* and *Aphis gossypii* were found to be additional vectors of the virus.

28. *Lettuce* (*Lactuca sativa* L.)

Mosaic.—The longevity *in vitro* of the virus was found to be between 24 and 48 hrs. when the sap extracted in 0.5% sodium sulphite was stored at room temperature (22.5° to 23.5 C.). In the host-range studies, the virus was successfully transmitted to *Pisum sativum* (producing transient mottle), while sweet pea and *Gomphrena globosa* proved to be symptomless carriers.

29. *Cardamom* (*Amomum subulatum* Roxb.)

(a) *"Foorkey" disease.*—In the host-range studies, the virus could not be transmitted to *Sorghum vulgare* (*jowar*), *Pennisetum typhpoides* (*bajra*), *Triticum aestivum* (wheat) and *Gladiolus gandavensis* when inoculated through viruliferous aphids (*Pentalonia nigronervosa*).

(b) *"Chirke" disease.*—Host-range of the virus was being studied. Also attempts to establish the vector were continued. In the varietal resistance tests, cardamom variety Sawney was found to be fairly tolerant.

30. *Papaya* (*Carica papaya* L.)

Mosaic.—In a search for the alternative hosts of the virus in nature, plants of *Trichosanthes anguina, Cucumis sativus, Cucurbita pepo, Coccinia cordifolia* and *Solanum melongena,* showing mosaic symptoms, were indexed on papaya seedlings for the presence of the virus, but gave negative results. Three varieties of papaya (Coorg Honey-Dew, Solo line-8 and Washington special) and three species of *Carica* (*C. microcarpa, C. candamarcensis* and *C. cauliflora*) were tested for their resistance to the disease. Only *Carica cauliflora* proved to be immune.

31. *Banana* (*Musa sapientum* L.)

Mosaic (*or chlorosis*).—The virus could not be transmitted by mechanical inoculation (pin-prick method) of the suckers with the infective juice. *Musa balbiziana* again proved to be resistant to the virus.

32. *Gooseberry* (*Physalis peruviana* L.)

Mosaic.—The virus was found to be readily transmitted through contaminated hands of the pickers at the time of picking berries during harvest.

33. *Mango* (*Mangifera indica* L.)

Malformation.—The disease was successfully transmitted in six more wedge-grafts. The disease also appeared in two more mango seedlings whose malformed shoots had been cut away, thus confirming the systemic nature of the disease. The role of eryophyid mites, which are found associated with the disease, was under study.

34. *Citrus* (*Citrus spp.*)

"Decline" disease.—Kagzi lime was found to be a useful differential test plant for testing the presence of "Tristeza" virus in *Citrus* spp. The presence of "Tristeza" virus was confirmed in *mosambi* and *kagzi* lime through grafting or budding on West Indian Key lime or *Kagzi* lime. Also, plants of grape fruit, *mosambi,* citron, *kagzi* lime, Italian lemon, Late Valencia orange and *Santra* were found to be affected by "Tristeza" virus when tested by means of *Toxoptera citricidus* on Key lime and *kagzi* lime seedlings. Indications have been obtained that *Aphis gossypii* and *Myzus persicae* are the additional vectors of the virus.

35. *Temperate Fruits*

"Line-pattern" of plum was successfully transmitted to plum varieties Manyard, Beauty, Satsuma and Santa Rosa; plum mosaic to plum varieties Beauty, Formosa, Mariposa and Manyard as also to stark Lambort Cherry; and mosaic of apple (variety Red Gold) to apple varieties Golden Delicious, Royal Delicious, Cox's orange pippin and several other local varieties. The virus nature of "Enation" of plum and mosaic of apricot was established.

36. *Development of new strains, Serological Relationship and Cross-Immunity Studies*

In the cross-protection tests carried out in tobacco plants with collection No. 17 and "S-isolate (producing systemic symptoms) of collection No. 1 of *brinjal* mosaic virus, it was observed that the former did not afford any protection to tobacco plants against the latter, indicating thereby that the two viruses are not related to each other.

37. *Isolation and purification of Plant Viruses and Study of their Properties*

The bottlegourd mosaic virus was purified and electron micrographs of the purified virus preparation showed that the virus particles are rod shaped.

38. *Virus-Vector Relationship*

Virus-vector relationship with regard to "Foorkey" and "Chirke" disease of large cardamom, "Grassy-shoot" of sugarcane and mosaic of broad-bean was studied. Single apterous aphids were found to be capable of initiating infection in all the cases. The virus of "Foorkey" disease of large cardamom was found to undergo an incubation period of 4 hours in the aphid vector, *Pentalonia nigronervosa.* The non-infective aphids were able to acquire the virus from diseased plants within 15 minutes of feeding period and infective aphids could transmit the virus to healthy plants in 10 minutes. The virus could also be transmitted by third instar nymphs of the aphid. In the case of "Grassy-shoot" of sugarcane, the adults of *Longiunguis pseudosacchari* acquired the virus in a feeding period of 20 minutes. *Aphis craccivora* acquired the broad-bean mosaic virus in 5 minutes from the diseased plants and initiated infection on healthy plants within 2 minutes. The nymphs were found to be more efficient as a vectors than the winged or wingless adults. The virus was further found to be of non-persistent type.

39. *Direct measures of control*

Field experiments on the direct control of tomato leaf curl by spraying against th vector (*Bemisia tabaci*) with different insecticides were repeated. Spraying with "Folidol-E 605" and "Ekatox-20" considerably reduced disease incidence, resulting in appreciable increas in yield as compared to the untreated controls.

In the experiments on the chemotherapeutic control of plant viruses, thiouracil a 1000 ppm., applied as soil-drenching at the rate of 200 ml. daily for 12 days, appeared t have suppressed the mosaic symptoms in papaya plants. In the case of "Chirke" disease o large cardamom, shoot infection with 0.001 to 0.1% thiouracil suppressed the mosaic symp toms in the infected plants.

40. *General*

Dolichos enation mosaic virus was transmitted to *Capsicum frutescens, Gomphren globosa, Cassia tora, Petunia hybrida, Phaseolus vulgaris* (var. Pinto), *P. lunatus, Impatien balsamina, Cyamopsis tetragonoloba* and *Dolichos lablab,* but was carried sypmtomlessly in *Kleinia fulgens, Physalis peruviana* and *Salvia officinalis.* The virus, however, did not pro gress beyond the inoculated leaves of *Amaranthus tricolor, Aster* sp., *Beta vulgaris, Spinacia oleracea* and *Phlox drummondii.*

Cassia tora was found to be a new and useful local lesion differential for tobacco mosaic virus. A virus causing yellow-net symptoms in tobacco was successfully transmitted to *Nicotiana tabacum* (var. *White Burley*), *N. rustica, N. glauca, N. campanulata, N paniculata, N. sylvestris, N. repanda, N. megolosiphon, Aster* sp. and *Beta vulgaris* by grafting or through the white-fly, *Bemisia tabaci.*

Cowpea mosaic virus was transmitted through seed and four species of aphids, namely *Aphis craccivora, A. gossypii, A. eronymi* and *Myzus persicae.* It was transmitted to *Vigna sinensis, V. sesquipedalis, V. cylindrica, Phaseolus mungo, P. limensis* and *Canavalia ensiformis* by juice-inoculation. The virus was found to have thermal-death point of 95-98° C., dilution-end-point between 1:30000 and 1 : 40000, and longevity *in vitro* of 12-13 days at room temperature (20-24 °C.) and of 20-21 days at low temperature (8-10 C.).

Lettuce mosaic virus was transmitted to *Pisum sativum,* but was carried symptomlessly in sweet-pea and *Gomphrena globosa.* Sida yellow-vein mosaic virus was transmitted to *Petunia hybrida, Zinnia elegans, Browallia elata, Kleinia fulgens, Nicotiana tabacum, N. glutinosa* and *Spinacia oleracea* through the white-fly, *Bemisia tabaci.*

The virus nature of yellow-net-vvin of mulberry was established.

D. Section of Systematic Mycology

41. *Taxonomy*

The emphasis, as in the previous years, has been on the study of plant pathogenic fungi, but considerable attention was also paid to fundamental studies of fungi belonging to different groups.

(a) *Plant Pathogenic Fungi.*—A leaf spot disease of wheat, caused by *Dilophospora alopecuri* (Fr.) Fr., was observed for the first time in India on the specimens received from Kashmir.

Studies on the genus *Colletotrichum* were in progress. It was observed that the fungi belonging to this group could be clearly divided into two catagories, one with straight spores and the other with curved spores.

Glomerella glycines in its conidial state (*Collectotrichum*) was recorded for the first me.

Continuing the studies on the genus *Cercospora,* a new species of *Cercospora* on rapes was encountered in the collections from Kulu area. Furthermore, about 30 new ngal or host records and five new species of *Cercospora* were reported.

(b) *Fungal parasites of insects.—Papularia* sp. on dead aphids, *Entomophthora aphidis* n *Bemisia tabaci* (white-fly), and *Gonatorhodiella* sp. on caterpillars feeding on *Dolichos blab* were reported. These are new records for India and two of them appear to be new ecies.

(c) *Group studies* (i) *Ascomycetes.*—Studies on Indian Erysiphales were in progress. en interesting records were made in this group, two of which are new species. *Erysiphe ikkimense* sp. nov. was reported on *Castanopsis tribuloides* and *C. indica.* Several powdery ildews in the conidial state were also collected. Efforts are being made to ascertain their erfect stages.

Two species of *Mycosphaerella, namely, M. minimaepuncta* (Cke.) comb. Nov. n *Gladiolus sp.* and *M. aethiops* (Cke.) Comb. Nov. on *Quercus* sp., were recorded. These pecies have not been reported from India so far. *Otthia quersicola* Ell. and Ev. on *Quercus* p. is also a new record.

About a dozen Discomycetes, mostly *Lachnella* spp. collected from Mussoorie, are eing studied.

Over half a dozen Ascomycetes, belonging to the other groups, were either new records r new species and are being studied further.

(ii) *Basidiomycetes.*—A large number of mushrooms growing in Delhi State, were tudied. Seven of these appear to be new records for India.

(iii) *Fungi Imperfecti.*—The largest number of speciments, examined during the year nder report, belonged to Hyphomycetes. Studies on several genera of this sub-class were nder-taken. *Alternaria tenuissima* (Nees ex Fr.) Wiltshire, which is normally a saprophyte r a weak parasite, was found to be widely prevalent on several hosts. This species has not been reported earlier from India. A new genus, *Corynesporella,* is proposed to be created as it differs from the closely allied genus, *Corynespora,* in certain characters. Several species of *Corynespora, Sporidesmium, Helminthosporium* and *Pestalotia* were also under study.

(iv) *Fungal Flora of Delhi.*—Of the 271 fungal specimens collected locally during the year and studied, 17 proved to be new records.

2. *Herbarium.*

In all, 595 mycological specimens (both Indian and foreign) were added to the Herbarium, bringing the total number of accessions to 26,539. One hundred and ten pecimens, including some Type specimens, were supplied to various Indian and Foreign cientfiic workers. World literature on the taxonomy of fungi and the list of specimens vailable in the Herbarium were being compiled. A supplement to the revised edition of Fungi of India" is almost ready for publication.

3. *Indian Type Culture Collection*

During the year under report, the total number of cultures in the Collection was ,106. In addition, 59 cultures of different rusts and 54 virus cultures were being maintained. bout 126 cultures were supplied to various scientific workers and Research Institutions in

the country and abroad. A revised list of the cultures available in the Collection was prepared

Studies on soil and mineral-oil preservation of fungi were continued. Of the 90 fungal cultures, preserved in Nujol or B.O.C. 120 during 1949-50, 60 were found to be still viable.

44. *Commonwealth Phytopathological News*

Four notes, containing scientific information on the latest researches of interest carried out in India, were communicated to the Commonwealth Mycological Institute, U.K., for publication.

PROGRAMME OF WORK FOR 1959-60

(a) *Plant Pathology*

(i) Studies on loose smut of wheat and barley, grain smut of *jowar*, bunts of wheat.

(ii) Determination of physiologic races of *Puccinia graminis tritici, P. triticina, P. glumarum, P. sorghi, P. hordei, Melampsora lini, Ustilago tritici, Tilletia foetida, T. caries, Neovossia indica* and *Colletotrichum falcatum.*

(iii) Studies on rusts of wheat, barley, sugarcane, linseed and sannhemp.

(iv) Green-ear disease of *bajra;* "Molya" disease of barley and wheat.

(v) Factors affecting variation in *Colletotrichum falcatum* and recurrence of red rot epidemics; origin of new strains of *C. falcatum;* evolving of cane varieties resistant to red rot and smut and the study of inheritance of their resistance.

(vi) Yellow ear-rot of wheat; stalk and ear-rot of maize; red-stripe of sugarcane; citrus canker; study of bacteriophages.

(vii) Nematode diseases; microorganism-nematode associations.

(viii) Screening of varieties of crop plants for their resistance to diseases, particularly rusts and smuts of wheat and barley; bunts of wheat; sugarcane and linseed rusts; pigeon-pea wilt and grain smut of *jowar.*

(ix) Microbial antagonism and antibiotics ; physiology of fungi ; physiology of parasitism; factors affecting virulence of isolates of *C. falcatum.* Effect of ionizing radiations on Plant Pathogenic Fungi and Viruses.

(x) Efficacy of different seed-dressing fungicides; laboratory, pot-culture and field-testing of proprietary fungicides and new compounds; chemotherapy; study of ecto-and endo-phytic fungal flora of stored seeds.

(b) *Plant Viruses*

(i) Mosaic disease of sugarcane, banana, papaya, *brinjal,* chilli, groundnut, plum, *Rubus ellipticus,* apple, line-pattern of plum, yellow-vein of *bhindi,* etc.

(ii) Phyllody of sesamum and other oilseed crops as also of *Brassica* spp.

(iii) Necrosis of tomato; "Foorkey" and "Chirke" diseases of large cardamom; "grassy-shoot" of sugarcane; small-leaf disease of cotton; mango malformation; virus diseases of citrus.

(iv) Virus-vector relationships of sesamum phyllody, banana mosaic, "grassy-shoot" of sugarcane and "Foorkey" disease of large cardamom.

(v) Purification of viruses; studies of properties of purified preparations; development of new strains and cross-protection tests; serological studies.

(vi) Control of sesamum phyllody and leaf curl, leaf curl of tomato, papaya mosaic, "grassy-shoot" of sugarcane. Screening of varieties for their reaction to different viruses and location of sources of resistance.

(c) *Assessment of Losses due to Certain Crop Diseases,* with particular reference to groundnut mosaic, papaya mosaic, linseed rust, angular leaf spot of cotton, *Helminthosporium* blight of maize, etc.

(d) *Systematic Mycology*

(i) Taxonomic study of new and unidentified collections available in the *Herb, Crypt. Ind. Orient.*; preparation of exsicatti sets of Indian Fungi, list of fungi deposited in the Herbarium and card-indices of species of fungi represented in India; collection of world literature of the taxonomy of fungi. Study of Fungal flora of Delhi; identification of fungi and disease specimens; taxonomic studies of Hyphomycetes, Meliolales, Erysiphales, *Alternaria, Cercospora* and *Nectria;* and maintenance of host index of fungi.

(ii) Maintenance of Indian Type Culture Collection of micro-organisms and their history sheets; study of methods for preservation of fungi and bacteria.

(e) *Miscellaneous*

Routine and advisory; post-graduate teaching and training of plant-protection and short-course students; assistance and advice to Indian Council of Agricultural Research and other Commodity Committees; Coordination of mycological and plant pathological research.

REPORT OF THE DIVISION OF SOIL SCIENCE & AGRICULTURAL CHEMISTRY

(Dr. R. V. Tamhane)

A. Agriculrural Chemistry

(a) *Soil Fertility*

1. *Fertilizer value of dicalcium phosphate*

Field experiments were conducted for the third year to test the fertilizer effect of dicalcium phosphate as compared to that of superphosphate on maize and wheat. Although significant differences in the yield were not obtained, the results indicate that dicalcium phosphate is a somewhat less effective source of P than super, particularly for short duration crops like wheat of which the requirement of P is low. The difference tends to level off for crops of high P requirement.

2. *Fertilizer value of diammonium phosphate*

Diammonium phosphate (20 % N and 54 % P_2O_5) was tested for its fertilizer value on paddy and wheat in pots at the rate of 40 lb N and 108 lb P_2O_5.

The yield of paddy grain was significantly higher with diammonium phosphate than with a mixture of ammonium sulphate and superphosphate containing the same amount of nutrients. A mixture of ammonium sulphate and diammonium phosphate applied at the rate of 40 lb N and 40 lb P_2O_5, however, gave higher yield than diammonium phosphate alone.

The differences in the yield of wheat grains under the above treatments were small and not significant.

Diammonium phosphate appears to be a more efficient source of nutrients than ammonium sulphate and superphosphate in Delhi soil. The disproportionate content of P_2O_5 in diammonium phosphate, however, may be made more economical by admixing with ammonium sulphate.

3. *Dipping of roots of paddy seedlings in nutrient solutions*

Roots of paddy seedlings were dipped, before transplanting, in water paste of soil and soluble fertilizer salts or insoluble nitrogenous and phosphatic fertilizer mixtures. In 10% solution of fertilizer salts enough soil is added to yield a paste that will stick to roots. Large increase in the yield was obtained by the use of ammonium sulphate, ammonium sulphate nitrate, urea-formaldehyde, ammonium sulphate plus dicalcium phosphate and blood meal.

4. *Slow acting fertilizers*

Urea offers possibilities of yielding a wide range of reaction products with formaldehyde, which may simulate the action of nitrogenous organic manures in liberating the nutrient at a well regulated rate according to the requirement of the crop.

Eleven products of this type containing 37.5 to 46% N were prepared and tested along with two imported products from USA and Japan.

Another type of product from which urea nitrogen is likely to be released slowly, was prepared by absorbing dissolved urea alone and in combination with ammonium sulphate and triple superphosphate in saw-dust, leaf powder, and dry dung in the proportion of 80% salts to 20% of the absorbing material.

The proportion of mineralised N was reduced as the proportion of formaldehyde in the product increased. Direct effect on paddy and wheat was not statistically higher than with urea but a regulated supply from the ureaformaldehyde products indicated somewhat better utilization of N by the growing crop. None of the products, however, showed any substantial residual effect. The organo-mineral absorbed products indicated promising scope for their production and use.

5. *Physical and chemical changes in certain fertilizers under different storage conditions*

Changes in physical condition and chemical composition during storage of ammonium sulphate, ammonium sulphate nitrate, calcium ammonium nitrate and four kinds of urea are being examined in different types of packing at five experimental centres. Results so far show that granular calcium ammonium nitrate keeps well in alkathene lined jute bags but not in ordinary jute bags or asphalt laminated crepe paper lined bags. Lump formation is most acute in ammonium sulphate inspite of no appreciable absorption of moisture. In preliminary experiments the caking tendency has been found to be significantly controlled by conditioning it with 2% terpentine oil having 5% wax dissolved in it.

6. *Cow dung gas plant*

Simple and cheap burners for cow dung gas, for cooking purposes in villages, have been fabricated.

A new design of the gas plant to utilise leaves, straw and other farm wastes is under test.

7. *Effect of phosphate manuring of berseem on soil fertility*

In a field experiment at the Institute Farm different doses of P as superphosphate are applied to berseem in rotation.

Maximum amount of N and organic matter is found in the soil receiving 64 lb P_2O_5 The combination of 56 lb of P_2O_5 as FYM plus 8 lb P_2O_5 as superphosphate, shows a higher N and organic matter in the soil as compared to a mixture of 8 lb of P_2O_5 as FYM plus 56 lb P_2O_5 or 64 lb of P_2O_5 as FYM or super alone. The available P_2O_5 in the soil is also the highest in plots receiving 56 lb P_2O_5 as FYM and 8 lb P_2O_5. The total P_2O_5 content has not changed to any appreciable extent on account of P-manuring.

8. *Cumulative effect of organic and inorganic fertilizers on the yield and chemical composition of wheat and maize.*

Under this experiment the seed is preserved from each replicated plot in the previous year and is sown in the respective plots in the succeeding year.

The yield of maize was more under organic manuring. Cumulative effect of four years' trial produced significant difference, FYM treatment being the best.

N and organic-C in the Soil decreased considerably under inorganic treatment. This has however displayed no significant effect upon wheat yield, though maize under this treatment recorded a rapid decrease in yield as compared to other treatments.

(b) *Microbiology*

9. *Nitrification of wild legumes in soil*

Nitrification experiments with wild legumes showed that *Aeschynomene aspara* is promising material for use as a green manure.

10. *Strain variation in rhizobia*

The increase in nitrogen taken up by the inoculated legume crops varied with different strains, ranging from 20.9 to 70.9 % in gram; 31.6 to 205.3 % in *methi* and 10 to 37.9 % in pea and 20 % in berseem.

11. *Rhizosphere effects on micro-organisms*

The rhizosphere of berseem supported a higher bacterial population as compared to the soil away from the root zone.

12. *Effect of vitamins and micro-nutrients on the microbiological activities*

Vitamin B was observed to accelerate nitrification by nitrosomonas and nitrogen fixation by Azotobacter at a concentration of 1 μ per 100 cc. Cobalt was observed to accelerate nitrogen fixation by Azotobacter at a conc. of 0.1 p.p.m.

13. *Bacterisation with phosphobacterin and Azotobacter*

In pot experiments with Delhi soil it has been observed that treatment of wheat seed with Azotobacter or phosphobacterin alone gave significant increase in the yield of wheat crop over uninoculated and unmanured plots. Azotobacter in the presence of FYM gave significantly increased yield over FYM alone. There was significant increase in the Azotobacter population as a result of inoculation.

In field experiments at Delhi significantly higher yields of berseem crop were obtained over control when inoculated with phosphobacterin, or Fosfo 24 or Indian culture of phosphorus solubilizing organism. Response was maximum with phosphobacterin which also released more P_2O_5 from rock phosphate or bone meal ro even super added to soil to which FYM was applied, as compared to Fosfo 24 or the Indian culture with berseem as test crop.

B. Soil Survey and Soil Physics

14. *Morphology and genesis of black soils formed from trap rock in Malwa plateau*

Morphology of a number of profiles from Indore showed the depth of solum was either shallow or deep depending upon topography. The profiles were characterised by a uniform dark-grey A-horizon with a sharp transition to C-horizon which was brownish white in colour and highly calcareous. The soils were alkaline and highly siliceous. As compared to the soils, the clay fractions were lower in silica and higher in alumina, thereby indicating that parent material was noticeable in the formation of these soils.

15. *Pedogenesis of Black and Associated brown and red soils*

Pedogenic study of these three different types of soils formed from granitic parent material in the same field along a single slope in Adoni (Andhra Pradesh) revealed topography to be the influencing factor in the formation of these soils. Although formed from

e same parent rock, light red soils are usually found on the elevated position of a slope hereas heavy black soils in the depression, the brown soils occupying the intermediate sition. The morphological, physical, and chemical characteristics followed the topo-quence in which these soils were found to occur. Depth of solum, pH, contents of clay, lcium corbonate, calcium, iron, aluminium, magnesium increase from red to black soils hereas silica decreases. Reverse is the trend in the composition of clay fractions of these ils.

This phenomenon has resemblance to the toposequence observed in the case of asso-ated soils in Raipur district reported previous year.

5. *Clay minerals in associated soils of Raipur district in toposequence.*

Kaolinite, illite, and montmorillonite which were identified by X-ray diffraction in he clay fractions of the associated soils of Raipur district, were found to occur in close ssociation in toposequence in the Raipur district (M.P.) Dominance of one or the other of nese clay minerals follow the same toposequence, viz., the dominance of Kaolinite and illite ecreases and that of montmorillonite increases down the length of the slope. Bhata soil vhich occupies elevated position of the slope contained predominantly kaolinite and illite vhereas Kanhar soils which occupy the depression of the slope contained predominantly nontmorillonite. In Matasi and Dorsa, occuping the intermediate positions of the slope, lite is predominant with traces of kaolinite. This observation is confirmed by the data on .e.c.'s and chemical composition of the clay fractions.

7. *Effect of continuous application of fertilizers and manures on the physical properties of soils.*

Investigation was started this year on the physical properties of soils from the 24 plots n the permanent manurial series at Pusa (Bihar) which had been receiving continuously the ame application of different fertilizers and manures and other cultural practices since 1908. Preliminary studies showed that the bulk densities were lower in the soils having application of FYM and green manure than those of the soils receiving inorganic fertilizers and no green manure as well as the control plots. This indicates better structure in the former soils.

8. *Soil loss and run-off in relation to intensity of rainfall*

Run-off and soil loss from the uncultivated bare run-off plots were observed to bear a ighly significant and positive relationship with the intensity of erosive rain. Under the ocal conditions, rainfall having an intensity more than 0.1 mm. per minute (equivalent to .24 iph) was found to be erosive, as concluded from the foregoing correlations and support-d by field observation. Soil detachment, as determined in adjoining similar plots with soil plash measuring technique, was inversely proportional to the vegetative cover and directly elated to the soil loss.

9. *Investigations of red soil formation in different climatic conditions and parent materials*

The climatic factors were found to be predominant in the case of basic rocks and the ffect of parent material was predominant in acid rocks in the formation of red soils. The oloration of red soils is due to hydration of free oxides. With the increase in rainfall and emperature laterisation has been found to be more intense. As the rainfall increases, the H and cation exchange capacity decrease with depth.

C. Physical Chemistry

20. *Fundamental studies on ionic equilibrium in plant roots*

The cation exchange capacity of fully grown plant roots grown in sand culture was found to be 9.2 m.e./100 grams of dry matter for wheat, 35.0 for mung and 49.1 for tobacco. The values obtained for the well grown plant roots on the Delhi soil were 9.09 for Bajra, 9.1 for wheat, 11.9 for barley, 13.3 to 14.4 for maize, 14.7 for Jowar, 22.3 for sunhemp, 22.5 for linseed, 27.6 for haybum, 30.2 for cowpeas, 33.4 for peas and 35.3 for gram. The potassium ion activity and potassium adsorption ratio of equilibrium solution were 0.11 m.e./litre and 0.097 respectively for wheat, 0.32 and 0.26 respectively for maize, 0.63 and 0.66 for mung and 0.78 and 0.76 for tobacco. Thus these values increased with the cation exchange capacity of the plant roots and would explain the relative need of these crops for potassic fertilizers.

21. *Potassium ion activity of different soils*

It was found that different soils give different soil test values at the same potassium ion activity and potassium adsorption ratio. This indicates that the limit of sufficiency will be different for the different groups of soils. On this basis, the soils can be grouped into different classes.

22. *Studies on the reclamation of saline and alkali soils of Pusa*

The application of 2.5 tons/acre of gypsum in five instalments and three floodings with about 6″ of water, with intercepting drains, have reclaimed one of the worst alkali affected areas at Pusa, for growing normal crops.

23. *Soil factors determining the quality of irrigation waters as regards their alkali hazards*

As a result of giving the same type of irrigation and growing the same wheat variety, NP-824 in lysemeters under identical climate at Delhi, different soils reacted differently indicating different extents in the alkali hazards of the irrigation water used. Amongst the soil factors which could explain these differences, the cation exchange capacity of the soil was found to be more important.

24. *Physico-chemical studies on the fertility of the soils due to clays and clay-humus complexes*

The physico-chemical properties of soils receiving FYM and incubated with and without the addition of bentonite were studied. Bentonite was found to increase the degree of aggregation of clay plus silt. Only the degree of aggregation of clay plus silt and the ratio of group I/II complexes were increased by the addition of bentonite in the Pusa and Agarthala soils. The incubation after the addition of FYM alone increased the degree of aggregation of clay plus silt in the Delhi soil but further addition of bentonite tended to reduce this increase. Thus bentonite can be applied to these soils for different purposes according to their need.

25. *Studies on cation-anion exchange capacity of soils*

On the basis of the cation to anion exchange ratio of soils, the soils generally fall into different groups. The soils studied so far fall into five groups.

D. Plant Chemistry

(a) *Organic Chemistry*

6. *Organic Thiocyanates*

A number of organic thiocyanates derived from terpene, prepared in this laboratory, ave not shown any outstanding insecticidal property.

7. *Chlorinated Insecticides*

Nopyl alcohol, bornyl alcohol and longifolyl alcohol were esterified with trichloroacetic cid and the trichloroacetates chlorinated to 33, 39 and 51% chlorine contents. The products e being tested.

8. *Synergists and formulations*

Nearly three tons of synthetic pine oil from Indian turpentine oil ex. *Pinus Longifolia* as been produced in the Sree Ram Institute according to the process developed at I.A.R.I. nd extensive testing of the material has shown that the product compares favourably with ne oil from natural sources.

9. *Fungicides*

The reaction between acetic acid and mercury in presence of hydrogen peroxide (100 ols.) and benzene is reported to yield phenyl mercuric acetate which is a powerful fungi- de. Since all the raw materials required excepting the mercury are available in India, the ossibility of applying this reaction to various hydrocarbons of the type benezene, toluene, aphthalene etc. is being investigated.

The derivatives of mercurated adduct from camphene and longifolene have been ound to possess powerful fungicidal properties and the one stage preparation of the latter om the hydrocarbon, mercury, acetic acid and hydrogen perioxide is being studied in de- il as it forms a convenient and inexpensive method of producing these compounds in bulk.

The preparation of p. tolyl mercuric chloride from p. tolyl sodium sulphinate, a by- oduct in the synthetic production of saccharine, was studied. The product was readily btained and its fungicidal properties were the same as that of pure p. tolyl mercuric chloride epared by other processes, but under the experimental conditions followed, the yield was w, C. 15 % only. Investigations are under way to ascertain whether increased yields can obtained.

10. *Pesticides of Botanical origin*

(a) The devolopment of rapid and simple methods of assay of pyrethrins in pyreth- m flowers is of great importance in the cultivation of new varieties. Preliminary experi- ents on the possibility of utilizing their unsaturation in the estimation of pyrethrins are ing conducted.

(b) In search for new plant insecticides of indigenous origin, the chemical consti- ents of roots of *Plumbago zeylanicum* are being examined in detail. This drug has been use for long in indigenous medicine as a powerful vesiccant. The first sample was obtain- locally and contained only 1-2% petroleum ether soluble material; the vesiccant com- nent occurs in this fraction. Screening in the Entomology Division showed that the

extract possessed some insecticidal potency. This result is significant since no plant in th family of *Plumbaginaceae* or related groups has so far been reported to contain any insec tisides.

Subsequent sample obtained from South India gave 12-15% of the petroleum ethe soluble fraction. Preliminary experiments with petrol extractives from fresh roots show tha they contain considerable amounts of a neutral fraction and further that the material solub in alkali contains considerable amounts of material other than plumbagin. The insecticid activity may be due to any of these different fractions. Arrangements are being made t procure and extract fresh roots of *P. zeylanicum* on a larger scale so that a detailed study c the different chemical components can be undertaken.

31. *Exploration of Toxicity Hazards in the use of Modern Insecticides. Scheme of I.C.A.R.* (Project of Entomology Division)

In continuation of earlier studies persistence of BHC and DDT residues after applica tion to food crops in 2.5-5 % dust and 0.1-0.2 % emulsion form were studied for maize bhindi, kakri, brinjal, tomatoes and cabbage against their respective pests, the harvestin taking place *C*-14 days after the final application in all cases. In case of dusts, the residue after 2-4 applications were below the tolerance limits. The emulsions gave higher residue than dusts in most cases and these were in some cases above tolerance limits.

The inward dislocation of BHC into grain when the latter is stored in sacks dusted with 5% BHC was studied. A slow movement of BHC into the outer-most layers of grain was observed.

32. *Improvement of essential oil yielding spices of India. I.C.A.R. Scheme* (Project of Botany Division)

Employing the method of hydro distillation a large number of samples of dill, fennel ajwain, coriander, caraway, anise and fennel leaves have been analysed. The possibility o increase in essential oil content of a particular spice being accompanied by correlations in the proportions of fixed oil, total carbohydrates or protein is being studied using dill as the specimen plant.

(b) *Biochemistry*

33. *Comparative efficiency of foliar and soil application of urea and superphosphate to maize*

In continuation of our earlier work on wheat and barley, a pot experiment with maize was conducted to evaluate the comparative efficiency of foliar application of urea and super phosphate with that of soil dressing of the same.

Two concentrations of N (1.87 and 3.73%) and P(0.88 and 1.76%) in factorial combinations were used in two and four frequencies.

The uptake of N was significantly greater from foliar sprays than from soil dressing. The greater uptake of N due to higher concentration of N in the spray and the effect of P on greater absorption of N from the spray was also significant. Greater production of dry matter was obtained with N application irrespective of their concentrations or modes of application.

The uptake of P was also greater from the foliar spray. NP interaction was positive d significant in sprays. The greater uptake of P from the spray was not accompanied by creased production of dry matter.

Foliar application of urea and superphosphate, therefore, appears to be superior to soil essing of the same, with respect of the uptake of N and P by the maize plant.

Nutritive value of wheat

Experiments were conducted to evaluate the nutritive value of promising Indian heats by determining the growth promoting value of young weanling rats. In preliminary periments with four wheats the nutritive value of NP 809 has been found to be the best, llowed by NP 823, NP 718 and NP 710.

Available micronutrients in Indian soils

Information on the available micro-nutrient status of Indian soils is not available. A w soil samples representing the major soil groups of India were, therefore, analysed for eir available copper and zinc by the bio-assay, method using *Aspergillus niger*. The soils ve shown a wide range of variation both in respect of their available copper and zinc ntent. Many of the soils were found low in their available copper and zinc content and ay respond to the application of the same.

Enzymes in plant mitochondria

Mitochondrial particles are the seats of multienzyems in which the activities of large number of enzyme are integrated and co-ordinated. Information on the presence of enosintriphosphatase in plant mitochondria is not available. This enzyme has been found be present in mitochondria prepared from germinated berseem. The first bile-P is released fast while the second labile-P is liberated at a slower rate. The third is ot attacked. The enzyme attacking ATP appears to differ from pyrophosphatase. β ycero-phosphate is not attacked by this mitochondrial preparation.

Nature of plant proteins

In the light of our earlier work, the release of amino acids from pulse proteins, during e early phase of pancreatic digestion, was studied by paper chromatographic technique. The lease of amino acids appear to differ from pulse to pulse.

During the first hour of digestion leucines and phenyl-alanine were released in addi-on to lysine and glutamic acid which were originally present in the free state in all the lses. Besides these, alanine was released in *mung,* gram and *arhar,* tyrosine in lentil and *har;* threonine in peas and *arhar.*

In the second hour of digestion methionine/valine was released in gram, *mung* and ntil; histidine/arginine in *mung* and gram; proline in *arhar;* alanine and glycine in peas.

Growth stimulating factor for lactobacillus leichmannaii

In continuation of the studies on the chemical nature of the growth stimulating factor *lactobacillus leichmannii,* it is found that the factor consists of at least two substances, e being dialysable and the other undialysable. The factors are not affected by hydrogen roxide and a part of the activity is soluble in ether. Hydrolysis with 2 N HCl inactivated e factors with the release of increased number of ninhydrin reacting spots. The undialys-le portion of the factor appears to be of peptide nature.

39. Phosphatases in the plant

In view of the possible implications of plant phosphatases in the utilization of phosphates when applied to the leaves and to the soil, its presence and kinetics have been studied in different tissues of berseem plant as well as in germinated berseem. Beta-glycerophosphatase and pyrophosphatase (acid and alkaline) have been found to be present in root, leaf and stem tissues of berseem. The relative activites of these enzymes appear to be of the same order in all these tissues. Their activity was, however, much pronounced in the germinated seed.

40. Synthesis of vitamin B_{12}-analogues by Azotobacter

Azotobacter has been found to synthesise certain vitamin B-like compounds, besides vitamin B_{12} itself. These different forms of vitamin B_{12} synthesised by Azotobacter have different Rf values, when tested by bioautography. Vitamin B_{12} was found both in the medium as well as in the bacterial cells.

41. Foliar application of nutrients to crops (ICAR-Scheme)

Studies on the effect of urea sprays on the yield and quality of wheat were continued. Experiments were conducted on wheat grown under both irrigated and rain-fed conditions. The combined effect of N & P spraying on wheat and potato has also been studied.

E. Physics

42. Electron Microscopic studies of viruses, clays etc.

The Phillips electron microscope was set up. The instrument was tested using a standard specimen of Polystyrine latex balls of known dimensions (2640 70 A) Preliminary work was started on viruses, algae, bacteria and clays in collaboration with other Divisions.

43. Micro-element studies

Statistical analysis of the measurements made for boron and manganese in citrus ash using pure and commercial copper rods indicated that in both the cases the deviations from the mean values were of the order of 14 % and 20 % respectively. This confirmed the possibility of substituting the commercial electrodes in the place of specpure rods for arcing.

F. Soil Testing Service

44. Fertility survey of 19 villages of the intensive cultivation scheme of the Delhi State villages

Soil Fertility maps of 19 villages showing their relative status of nutrients were prepared on the basis of the analytical data of 3000 samples collected from them at the rate of one composite sample for 5 acres. The results show that almost all soils are low in nitrogen content and contained moderate amount of available P. As regards potassium these soils may be considered to have enough available K.

45. Estimation of available potassium in soils and correlation with crop responses

Studies on the available potassium and its correlation with crop responses have been conducted with the following results.

(1) The nature of the extractant, the details of extraction, the texture of the soils the type of the clay mineral and the nature of the crop have all been found to influence the correlation values between soil tests and crop responses.

(2) In the case of light soils for paddy crop in pot culture a good correlation coefficient (0.97) was obtained between exchangeable potassium percentage values and crop responses.

(3) Soils having montmorillonite as the predominant clay showed no response to the application of potassic fertilizers while those of kaolinite showed good response.

(4) In clayey soils, there was a significant correlation between % K response and % K in the plant.

These investigations have shown that plant analysis on clayey soils and soil test values on the light soils have their respective sphere of usefulness for correlating with crop responses on paddy.

46. *Preparation of all India soil test summaries*

The all India soil test summaries prepared upto November, 1958 indicated the following trends in the fertility levels of different areas in India. About 50,000 samples have been analysed for available phosphorus and these indicated that 45 % are low, 31 % medium, 24 % high with respect to this element .With regards to postassium, analysis of 22,000 soils indicated that 25 % are low, 36 % medium, and 39 % high with respect to this element. For available nitrogen analytical results of 20,000 showed that 68 % were low, 20 % medium and 12 % high in this nutrient.

47. *Estimation of available nitrogen and phosphorus in soils and correlation with crop responses.*

Correlations between soil test values of typical agronomical experimental centres and crop responses obtained in pot culture and field experiments were evaluated. Out of the methods used for inorganic and organic nitrogen, alkaline $KMnO_4$ methods gave the maximum correlation in both wheat and paddy crops in Delhi soils. With regard to the methods of available phosphorus, *Bingham's* method and Versene flouride method gave highest correlations in Delhi soils.

An attempt was made to evaluate the differences in the performance of the crop between pot culture and field experiments. The coefficient of correlation obtained between control yields of pot culture and field experiments was found to be 0.5 on all India basis, indicating that the different environments in both the cases have contributed to the lack of identity of trend between pot culture and field experiments.

48. *Sub-soil nutrient availability to deep rooted crops*

The root distribution of sugarcane was found to penetrate up to about 3 ft. and a study was made regarding the availability of nutrients at depths below the surface layer in some typical soils where surgarcane Co. 419 is grown in India. These studies have indicated that there is steady decreasing trend of nutrient availability with depth, and deep placement of nutrients in such soils is likely to give good responses, hitherto not obtainable by surface or small depth placements.

49. *Correlation of soil tests with response of wheat to the application of phosphorus and potassium on some Indian soils*

Green house experiments were conducted with soils collected from different parts of India and the responses to phosphatic and potash fertilizers were correlated with soil test values obtained by different methods. For phosphorus, the following methods employing acid extractants gave significant correlations with crop responses : (1) Spurway—0.135 N HCl, (2) Morgan's method 3% acetic acid buffered to pH 4.8, (3) Bray's method 0.1 N HCl in 0:03 N NH F and Truog's method 0:002 N H_2SO_4 buffered to pH_3. For potash, many of the soils did not respond and hence most of the correlations were not significant.

G. Radiotracer Investigation

50. *Available phosphorus in soils and phosphorus fertilizer utilisation by paddy and wheat*

Pot culture experiments with paddy and wheat have been carried out on different soils for three years. These experiments had 0, 40, 80 and 160 lbs. P_2O_5/acre applied as radio active superphosphate over a basal dose of nitrogen, potassium and other trace elements. Phosphate response curves for the crops have been drawn. Mean response curves for various groups of soils which had responded to phosphates and had responses greater than 75 % 50-75 %, 25—50 % and 25 % have been worked out. In general, the plateau of the response curves starts at 80 lbs P_2O acre dose—this has been observed in all soil groups. Highly significant exponential inverse relationship has been found between the logarithm of 'A' values and percentage yield response in both paddy and wheat.

51. *Fixation and exchange of phosphorus in soil*

The purpose of this study was to describe the phosphate fixing characteristics of Indian soils. Total phosphorus fixing capacity, exchange adsorption, unsaturation, differential fixation, intensity of fixation and movement of phosphorus were therefore studied on 70 different soils. The percentage phosphorus fixing capacity was found to be influenced by pH, sesquioxides, moisture equivalent and exchangeable bases of which, as revealed by standard partial regression coefficients, sesquioxides showed a comparatively dominant effect. Within 1 to 4% $CaCO_3$ the percent fixing capacity showed almost linear relationship but at higher content there was a tendency to level off. Probably what is more important is the overall surface rather than the actual content. Binding energy of phosphates in alkaline soils was not much varying but in acid soils the range was wide. While pH and organic carbon were negatively related with binding energy, sesquioxides showed a positive relationship. Further studies revealed that organic matter in these acid soils influence the tenacity with which phosphorus is attached to the sesquioxides. In other words binding energy is determined not by sesquioxide alone but by ratio between sesquioxide and organic matter. For same sesquioxide content, a laterite soil with poorer organic matter content had much higher binding energy than a hill soil with higher content of organic matter. In another study it was found that bulky organic matter significantly increased the movement of phosphorus in soils. Considering therefore the overall beneficial effects of organic matter in reducing the binding energy and in increasing the movement of phosphorus, its role in conjunction with phosphate fertilization practice should be very important.

2. *Comparative efficiency of phosphatic fertilizers*

Pot culture experiment with rice was carried out on eight different soils. Uptake of otal and fertilizer phosphorus was determined at several stage of growth: 3 weeks, 6 weeks nd 10 weeks. It was found that percent phosphorus in plant derived from fertilizer from ll soils reached maximum between 3 and 6 weeks after which it levelled off. This was true rom all fertilizer sources, also. It was found that in acid soils ammonium phosphate follow-d by metaphosphate were far superior to superphosphate or other phosphatic carriers. In ARI soil from both top block and main block there was practically no difference between he carriers. This confirms our previous year's observations. In a residual effect study with wheat on these soils it was found that there was a significant correlation between available hosphorus of these soils with residual effects (as determined by NaHCO method) and 'A' values determined from percent phosphorus in plant dervied from applied radio-active ertilizer.

53. *Effect of organic matter, silicates and chelates on uptake and utilisation of phosphorus by paddy and wheat*

In the wheat experiment four soils and in the paddy seven soils were used. In wheat, it was found that under the influence of organic matter, uptake of phosphorus increased significantly over control in all soils but the yield increase was significant only in Pusa calcareous soil. Laboratory data showed that available phosphorus was also increased under this treatment in all soils. Data clearly indicated that in Pusa soil superphosphate applied with manure was very beneficial—though singly they were not so. O ganic matter decreased the uptake of fertilizer phosphorus at all stages of growth. Silicate did not show any effect in the early stage either on yield or uptake of phosphorus. At harvest stage silicate increased the yield in Pusa and Delhi soil and uptake in all soils. The effect of chelate varied with the soil. It reduced the phosphorus fixing capacity of the soils but it usually exerted a tonic effect on growth. In paddy also conclusions were the same.

54. *Decomposition of bulky organic matter in soils and nutrient availability*

The method for estimation of total and radio-carbon in plant material was standardised. A chamber for incorporation of radio-carbon in growing plants was set up and C tagged berseem and oats obtained.

Programme of work for 1959-60

Soil Fertility

1. Fertilizer response in respect of yield of crops and uptake of nutrients :—
   Experiments with diammonium phosphate, coating of wheat & maize seeds with insoluble fertilizers, sodium chloride along with fertilizers on wheat & paddy. Anhydrous and other liquid fertilizers on crop growth.
2. Soil fertility investigations under continuous manuring and crop rotation studies.
3. Use of ammonium chloride as a source of nitrogen to crops with special reference to the effect of chlorine on growth and crop composition.
4. Effect of continuous use of F.Y.M. and inorganic NP fertilizers and their combination on the yield and chemical composition of wheat and maize using the same seed obtained from the same plot in the previous year.

Soil Microbiology

1. Studies on the rhizobium of wild leguminous plants. Strain variation in rhizobia in some common cultivated legumes.
2. Studies on the relation between the efficiency of different strains of rhizobia and their characteristics.
3. Studies on introgen transformation using stable isotope N^{15} .
4. Ecology of acid tolerant azotobactor.
5. Rhizosphere effects on micro-organisms.
6. Studies on the effect of micronutrients and vitamins on the microbiological activities.
7. Studies on bacterisation, phosphobacterin, Azotobacterin in neutral and alkaline soils, Azotobacterin in acid soils.

Soil Survey and Soil Physics

1. Studies on Indian Soils : Genesis, morphology and classification.
2. Minerological studies of soils, clays and parent Materials.
3. Studies on soil structure. Effect of manures, fertilizers, cultural practices and soil conditioners on soil structure and related soil properties.
4. Studies on soil moisture: pF, curves and moisture relationships of typical Indian Soils.
5. Run-off and soil loss Experiments : Effect of soil treatments on the infiltration run-off and soil loss.

Physics

Physical Chemistry :—

1. Studies on the ionic exchanges in soils, clays and clay minerals and plant roots.
2. Electro-Kinetic properties of alumino-silicate precipitates, clay minerals and soils in relation to formation of clay minerals.
3. Studies on the separation and properties of clay and clay humus complexes from soils.
4. Studies on the activities of ionic nutrients in various types of soils, clays and clay minerals in relation to their availability to plants.

Organic Chemistry :—

1. Synthetic pesticides :—

   Synthesis of organic compounds containing various toxophoric groups as possible insecticides; synergists for insecticides; formulation of pesticides; fungicides; weedicides.
2. Pesticides of Botanical origin—Improvement in pyrethrum and examination of indigenous plant materials for pesticides.
3. Exploration of toxicity hazards in the use of modern insecticides (ICAR project).
4. Improvement of essential oil yielding species of India (ICAR project).

Biochemistry :—

1. Quality of crops as influenced by manurial, cultural, and management factors.
2. Nitrogen metabolism in plant.
3. Studies on plant enzymes.
4. Available micro-nutrients in the soil.
5. Studies on plant metabolism with the use of radio isotopes.
6. Foliar application of nutrients to crops.

(I.C.A.R. Scheme).

Physics

1. Standardisation of spectrographic, spectrophotometric and polarographic methods of estimation of micro-elements.
2. Study of the micro-elements status of the Indian soils.
3. Qualitative identification and qualitative estimation of clay minerals in soils by X-Ray diffraction technique.
4. Electron-microscopic studies of virus, algae, and clay minerals for their identification and structural studies.

Soil Testing

1. Evaluation of soil test correlation in pot and field experiments for NP and K.
2. Fluctuations in available nutrients with season crop and both.
3. Availability of nutrients in sub-soils and their evaluation in soil test crop correlation.
4. Evaluation of fertility on all India soils and soil test summaries.

Radio-tracer Investigations

1. Available phosphorus in soil and phosphorus fertilizer utilization by paddy and wheat.
2. Comparative efficiency of different phosphatic fertilizers for crops from different soils.
3. Placement studies with phosphatic fertilizers on linseed, potato and cotton (in collaboration with Agronomy Division).
4. Decomposition of bulky organic matter in soils and availability of nutrients.
5. Spray fertilization of phosphatic fertilizers *VS.* normal application.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING

(Shri E. G. K. Rao)

General

(a) The following machines and implements were purchased during the year to form a part of the permanent equipment of the Division :—

Sl. No.	Name of machines or implements	Received from
1	One Otto frame unit	M/s Voltas Ltd., Bombay.
2	One seed-drill	Agricultural implement, Research Station Neelgaon.
3	One draw bar dynamometer	M/s Roadless Ltd., Middlesex, England.
4	One Ajax electric engraving pen (complete set)	M/s Bhaknwala & Sons, Bombay.

(b) 1. Large number of enquiries were received during the year pertaining to engineering aspects of agriculture from private individuals, Institutes as well as public bodies and State Governments. Most of the enquiries related to selection, use and operation of agricultural machinery and appliances. From the queries received during the year, there appears to be a growing and keener interest in the use of small walking tractors, for agricultural purposes. The Government of India have accordingly decided to obtain 40 Land Master tractors which will be immediately put to countrywide trials to determine their utility and economy under Indian conditions.

2. Technical advice was rendered to the Ministry of Food & Agriculture on problems connected with mechanized agriculture as well as import and export policies relating to agricultural implements machines and other appliances.

3. Advice was also rendered to other Divisions and sub-stations of the Institute in connection with selection, procurement, installation, operation and maintenance of agricultural machinery and equipment including processing plants such as grain driers.

(c) The Agronomy Division indented the services of this Division in carrying out the repairs of tractors, steam engines, oil engines etc. and also farm implements and machines under their charge.

(d) The Activated Sludge plant had been under the technical and administrative control of this Division throughout the year, and the capacity of the pumps has been enhanced to take care of the excess load of sewage.

(e) *Supply of Drawings.*—This is a special service feature of the Division. Many requests were received from individuals and private as well as government bodies for supply of working drawings to facilitate the manufacture of a particular implement or machine. Blue prints of drawings were supplied to private parties at an approved rate of Rs. 5/- per set and free to the Government bodies—10 sets of drawings have been supplied during the year and Rs. 20/- were received in cash for those supplied on payment.

Schemes

(1) *Museum of Agricultural Machines and Implements*

The work of the scheme has been started after the appointment of an officer in the month of November 1958. All the implements and machines which were available in the Division for display, have been arranged in the new building of the museum. Action has also been taken to procure the implements and machines which have been reported in the survey scheme but are not available in the Division. The Director of Arts, I.C.A.R., has been consulted for planning the display. The working data of all the implements and machines exhibited in the Museum is being collected. Tests of the implements which have been tested are also being taken up. A list of indigenous implements to be obtained for the museum has been prepared and action taken to procure them from the various state Directors of Agriculture. Some Japanese implements are also being obtained. The available performance data of the implements is being collected and the programme for testing implements is being drawn up.

(2) *Survey of indigenous agricultural implements in common use in the country*

The draft all India report of the scheme has been completed. The survey had been in progress since 1954 and the no. of types of implements of indigenous origin are as summarised below :—

S. No.	State	Plows	Harrows	Hoes	Seed-drills	Sickles	Planks & levellers	Rollers	Ridgers	Total
1	Andhra	12	7	6	5	..	..	..	..	30
2	Assam	5	3	..	..	1	..	..	..	9
3	Bhopal	1	2	1	2	..	..	..	..	6
4	Bihar	13	..	6	..	7	3	..	..	29
5	Bombay	22	20	16	32	3	2	1	..	96
6	Coorg	3	3	2	2	1	1	2	..	14
7	Himachal Pradesh	4	2	1	1	3	..	3	..	14
8	Hyderabad	24	20	11	18	..	..	..	1	74
9	Madhya Bharat	7	8	6	11	..	1	..	..	33
10	Madhya Pradesh	10	7	5	14	..	..	6	1	43
11	Madras	14	6	15	7	8	7	..	..	57
12	Mysore	14	20	2	4	..	..	..	..	40
13	Orissa	12	1	..	..	2	5	..	..	20
14	Punjab	16	6	8	7	..	3	7	1	48
15	Rajasthan	14	..	..	..	2	..	..	..	16
16	Travancore-Cochin	9	1	..	..	..	2	..	..	12
17	Uttar Pradesh	21	3	6	5	11	..	7	4	57
18	Vindhya Pradesh	2	2	..	2	..	..	1	..	7
19	West Bengal	4	2	2	..	2	3	..	1	14
		207	113	87	110	40	27	27	8	19

The Committee have approved the draft and have recommended its publication by the I.C.A.R. The State Agricultural Engineers have in the mean time, been advised to take up research work on the lines of recommendations embodied in the report, which have been abstracted and circulated to the various States.

(3) *Establishment of Research-cum-Test Centre for Bullock operated implement—I.A.R.I. Centre.*

The scheme has been sanctioned and action has been initiated to recruit the staff and to procure the equipment etc. for the centre. Out of the four centres proposed to be established by the I.C.A.R. in different States, one has started functioning in a limited way at Delhi attached to this Division with the appointment of a few Junior Staff. The specifications of the requirement as well as proposals for procuring some implements are being worked out.

(4) *Scheme for Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements.*

The reports of the implements received from States have been compiled. As all the States have not submitted the reports, action has been taken to expedite the same.

(5) *Survey of Additional Agricultural Implements*

The Agricultural Engineering Committee, considering that the data collected during the scheme regarding the implements and included in the report was of considerable interest, recommended that the survey should be extended to implements not covered under the earlier survey. On the recommendations of the Agricultural Engineering Committee the I.C.A.R. decided that a new scheme entitled Survey of Additional Agricultural Implements may be started on the same lines as the original survey scheme with minor modifications, and the data of all the remaining implements namely processing machines, bullock carts and water lifts etc. which were not covered by the earlier should be collected. For this purpose 4 posts of Class I Junior Officers have been sanctioned who are to be stationed at New Delhi, Lucknow, Poona and Cuttack and who will be responsible for collection of the data with the assistance of the field staff located in the States on bullock carts, water lifts, ground-nut decorticating and processing machines, chaff cutters, rice processing machines etc. The non-gazetted staff at the I.A.R.I. has been appointed, but work however, can only be taken up after the remaining 3 Jr. Class I Officers and the staff are appointed in the States. Meanwhile proformas for collection of data which was scrutinized and approved by the Agricultural Engineering Committee of the I.C.A.R. have been got printed.

(6) *Coordinated Scheme for import and trials of Agricultural Implements*

The I.C.A.R. have sanctioned a scheme for testing the agricultural implements which are to be imported from abroad and those which have already been used in India and found useful but which are not widely popular throughout the country for some reason or other. Proformas for conducting the tests have been prepared and detailed test procedures evolved.

Research

.. *Development of sowing and fertilizing machines*

(i) *Bullock Drawn Seed-Drill.*—A bullock drawn seed-drill was designed and fabricated for sowing wheat, barley maize etc. The machine is capable of sowing three rows at a time with fluted roller type seed metering mechanism. The drive of this machine is obtained from one of the two ground wheels provided at the rear of the drill. The ground wheels are also used in transporting the drill from place to place. The seed metering mechanism can be put out of action by a simple dog clutch mechanism which is operated through a handle provided within the easy reach of the operator.

(ii) *Fertilizer placement*-cum-*sowing machine.*—A bullock drawn single row fertilizer placement-*cum*-sowing machine has been designed and developed by this Division. The machine has separate chambers for storing seeds and fertilizers. The seed dropping mechanism is of fluted roller type, while the device for placement of fertilizer in lands on both the sides of the seed drilled, is of worm feed type. Both of the devices have been mounted on a common shaft. The machine is still under development awaiting preliminary field trials.

(iii) *Sowing Machine.*—A bullock operated seed-drill was designed and fabricated for sowing wheat, barley, maize etc. In the first instance a single row machine was manufactured and tried in the field with maize seeds. It was possible to drill 2 to 3 seeds at a time at an average distance of 9 ″—10 ″. None of the seeds was damaged as was evident from the fact that the germination was 100 percent. As the results of the trials of the single row machine was encouraging, a four row working model was manufactured. The machine is at present awaiting field trials.

(iv) *Development of Bullock Gear.*—Work has been taken up to design and develop a bullock gear which could be used for utilising bullock power for operating various agricultural machines. A bullock gear has been designed and a small working model has been fabricated. The working of the model is satisfactory. The model is under study in order to study the feasibility of an actual working scale.

(v) *Groundnut Planter.*—A two-row groundnut planter has been fabricated, incorporating the patented seed-picking mechanism evolved by the Division. The design is a sequal to a one-row model which was subjected to extensive field trials in groundnut growing regions of the country. The machine is under field trials.

(vi) *Development and trials of engine for working on cow dung gas.*—Work has already been done to develop a suitable Chula and its running arrangements for use on the cow dung gas. Efforts are now being made to develop or modify an engine which could be used with the gas and develop about 3-4 H.P. with an average size plant. Some preliminary work has been done with small petrol engine available after carrying out some modifications. The results have been encouraging. Further work is being taken up. A scheme for taking up the project for development of engine has also been prepared and submitted.

(vii) *Development of Bullock Drawn Tool Bar.*—Work is in progress for using the carriage of the German plough as a tool bar so that various farm implements can be used with it. A seed-drill which could be mounted on the carriage, whenever desired, is now under development. A seed-box, feed rollers and fertilizer dropping device have been assembled and arrangements are being made to fit them on the carriage. Power for running the mechanism would be derived from the axle of the carriage.

2. *Experiments with Tillage Implements*

Trial of Triphali.—One triphali submitted by Shri Patel was put to field tests. The implement has three tynes and a long wooden beam. The weight of the triphali was 56 lbs. out of which iron parts weighed 41 lbs. The beam which was of wood was 10 feet long. The details of the tests are as follows :—

S. No.	Centre to centre width in inches	Depth in inches	Speed in m.p.h.	Draft in lbs.	Area of furrow in sq. inches	Unit draft in lbs.	Output/hr acres
1	16	5	1·45	360	91	3·95	·375
2	11½	5	1·3	285	63·75	4·4	·3
3	8½	6	1·46	240	61·00	3·93	·25

It was observed during trials that the triphali left dead furrows in between the tynes and the draft was too heavy. Due to narrow spacing of tynes there was too much of chocking and instead of just breaking open the soil a furrow was formed due to this packing. Too close spacing of tynes increased the choking considerably and dragging of soil was occuring frequently. There would therefore appear to be a limit to which the spacing of tynes could be reduced without experiencing chocking up. The triphall was not found useful as a substitute for plough and could only be employed after irrigation for inter culture. The implement is light in weight, simple in construction and has the facility of adjustable tyne spacing.

3. *Experiment with Harvesting Machines*

Austrian Scythes.—The Austrian scythes were put to further field tests at Agricultural Sub-Station, Karnal for harvesting wheat and following observations were made.

No. of treatment	Duration of test Hr. Mts.	Area cut sq. ft.	Crop density per sq. ft
A. One man with scythe cutting and gathering	6—30	10712	23
B. Two men with scythe one cutting and other gathering	20·00	51467	20·5
C. Two men with scythe cutting gathering alternately	29.30	85716	22·5
D. One man with sickle cutting and gathering	6—30	7362	22·00
E. Two men with sickle cutting and gathering	6—30	8694	20·25

It was ensured during trials that no uncut crop was left out either by scythe or sickle and in both the cases clean cuts were obtained. Approximately ¾th of the time of the man who was collecting and tieing the cut material was wasted in case of sickle while the man provided with scythe for the same purpose was able to keep himself continuously busy.

The consolidated data of all treatment *i.e.* A, B, C, D & E showing the area harvested er hour, per day etc. are given below :—

Treatments	Area cut per hr. on sq. ft.	Area cut in 8 hrs. sq. ft.	Acres
Scythes			
A . .	1648	13184	·3
B . .	2523·35	20186·80	·46
C . .	3007·4	24059·2	0·55
Sickle			
D .	1133	9064	·208
E .	1137·5	10700	·24

It was found that two men working with a scythe could harvest about 0.5 acre per day of 8 hours when cutting and collecting alternately whereas with a sickle only 0.2 acre was possible to harvest.

Further trials will be conducted with the scythe for cutting other field crops.

4. *Experiments with threshing machines*

The olpad thresher has been modified for producing fine Bhusa and for increasing its range of utility for other crops also. The modified olpad thresher which was sent to the Agricultural Sub-Station, Farm Karnal for test under farm conditions and was tested to compare its functioning in relation to out-put, efficiency etc. with that of an unmodified olpad thresher. 80 maunds of harvested wheat crop from 1.5 acres of land was threshed with each olpad thresher. These machines were worked side by side for the same period and the following observations were recommended.

Modified Olpad Thresher

Date	Time worked	Hrs. Worked	Observed draft lbs.	Sample	Time of taking samples	Remarks
13-5-59	8·40—10·15	1·35	..	..	..	..
	10·30—12·00	1·30	..	..	..	..
	14·10—15·30	1·20	..	..	..	..
	15·50—17·45	1·55	120	..	..	Draft recorded at 16·30 hrs.
	Total for the day	6·20				
14-5-59	07·45—10·50	3·05	..	..	..	..
	11·10—12·00	0·50	..	..	..	..
	14·15—17·45	3·30	107·5	—A1	16·30	,, 16·10 hrs.
	Total for the day	7·25				
15-5-59	8·05—12·00	3·55	105	..	..	,, 10·00 ,,
	14·00—17·35	3·35	105	A2	16·30	,, 15·00 ,,
	Total for the day	7·30				
16-5-59	8·00—10·15	2.15	107·5	A3	8·45	,, 9·00 ,,
	10·30—12·00	1·30	100	A4	..	..
	14·05—17·45	3·30	100	A5	14·15 & 17·25	,, 15·00 & 17·30 hrs.

Unmodified Olphad Thresher

Date	Time worked	Hrs. Worked	Observed draft lbs.	Sample	Time of taking samples	Remarks
13-5-59	8·40 —10·15	1·35	..	..	..	..
	10·30—12·00	1·30	..	..	..	..
	14·10—15·30	1·20	..	..	..	..
	15·50—17·45	1·55	110	..	..Draft recorded at	16·30 hrs
	Total for the day	6·20				
14-5-59	7·45—10·50	3·05	..	..	..	..
	11·10—12·00	0·50	..	..	..	..
	14·14—17·45	3·31	95	B1	16·30 ,,	16.30 hrs
	Total for the day	7·26				
15-5-59	08·05—12·00	3·55	95	..	.. ,,	10·00 ,,
	14·00—17·35	3·35	95	B2	16·30 ,,	15·00 ,,
	Total for the day	7·30				
16-5-59	08·00—10·15	2·15	100	B3	8·45 ,,	9·00 ,,
	10·30—12·00	1·30	92·5	..	..	..
	14·05—17·45	3·40	90	B4 & B5	14·15 & 17·25 ,,	15·00 & 17·30 hrs
	Total for the day	7·25				

Scrutiny of samples.—Samples taken from both threshers were analysed and subjected to scrutiny. The following results were obtained.

Samples	A1	B1	A2	B2	A3	B3	A4	B4	A5	B5
Unthreshed wheat to threshed wheat	x	x	15%	27%	4%	21%	12%	21%	9·6%	15·2%
No. of straw pieces per gramme	x	x	158	93	290	174	338	192	409	260

It is seen that the sample A2 taken at 16.30 hours on 15-5-59 has the same analysis as sample B5 at 17.25 has on 16-5-59, the first after working 20 hours and 10 minutes and the 2nd after 28 hours 20 minutes. This is a saving in threshing time of 8 hours and 10 minutes can be attributed to the use of the modified olpad threshers. The modified olpad thresher has done 490/1210 × 100 or 28.8% more than the unmodified olpad thresher. The draft of the modified thresher was higher by about 9 to 12% and also is likely to cost 20 to 25% more.

Appliances for preparation of Land for Irrigation

Irrigation and water measuring devices

(i) *Bullock Drawn Float.*—One float designed and developed in this Division was ied in the top-block of the Agronomy Division. The following observations were made.

Levels observed before use of float R.L.	Difference in levels	Levels observed after use of float R. L.	Difference in levels after use of float	Distance from the road side end of the field
30·45		730·57		20·0′
30·73	0·28′	730·57	0·0′	20·5′
30·47		730·48		60·0′
30·63	0·26′	730·49	0·0′	60·5′
30·47		730·64		80·0′
30·76	0·29′	730·64	0·0′	80·5′
30·49		730·60		100·0′
30·77	0·28′	730·58	0·02′	100·5′
30·68		731·71		120·0′
30·85	0·17′	731·71	0·00′	120·5′
30·56		730·80		140·0′
31·00	0·44′	730·80	0·00′	140·5′

It is quite evident from the data collected during trials that the levelling and smoothng was achieved within two hundredth of a foot. Efforts are being made to design a loat for use with a single pair of bullocks.

(ii) *Parshall Flume.*—Accurate control and measurement of water is essential for fficiency in irrigation and conservation of irrigation water. A parshall flume, for the purose of measurement of irrigation water has been designed and constructed. It has been alibrated and installed in the farm of the Agronomy Division. The following data was bserved during tests.

Gauge reading . . . . . •2

ischarge . . . . . 0·046 cusec or 19·96 P.M.

Working head downstream throat in orifice taking off from the main water course–0.3
The observed discharge was 1.12 Cousec.

6. Appliances for use with cow dung gas Plant

(i) *Chula.*—A simple village model working stove has been evolved and an experimental model fabricated. The main attraction of the Chula is the wide range of control of flame size and the possibility of using cheap local material. The gas is admitted to the base of Cylinderical container fitted with stonepieces. The gas in rising through the layer of stone diffuses not only over a large area, but also has a lower efflux velocity with the result that flame burns in a stable manner over the bed of stones over a wide range of gas feeds. The device is under experimentation with a view to evolving an improved model.

(ii) *Cow Dung Gas Lamp.*—Experiments are in progress with the object of evolving a satisfactory incandescent lamp using cowdung gas under low pressure.

7. Trials of Tractors

(1) *David Brown 2 D Tractor.*—A 4 wheeled David Brown 2 D tractor having 2 cylinder, 3.5″ bore × 4.0″ stroke, air cooled 14.1 B.H.P. diesel engine, was received from M/s. Mahendra & Mahendra Ltd., New Delhi for tests. The tractor was tried in the field of Agronomy Division for various field operations for a total duration of 50 hours, over a period of 17 days. Throughout the tests, the tractor was operated by the firm's representatives, and all data was recorded in the presence of the firm's representative. The ploughing tests were conducted with a two way mounted plough submitted by the firm after removing the skimmer under different conditions. In order to get an idea of the approximate loading on the tractor a 9″ victory plough operated by a pair of bullocks was also worked in the same field alongside the tractor and the pull exerted by the bullocks was recorded while ploughing to various depths. The unit draft resistance thus obtained was used to calculate plow load resistance on the tractor.

The quality of work turned out during ploughing is good and the maximum depth of ploughing is about 8 ″when the output was found to be 0.206 acre per hour and the fuel consumption was found to be 0.472 galls. per hour or 2.19 galls. per day.

The tractor is fitted with a compressor delivering air at 140 lbs. per sq. inch and is therefore, suitable for working directly pressure operated pneumatic devices. This is also convenient for inflating the tyres of tractors and for cleaning.

The tractor has a very short turning radius of about 8′. This is particularly attractive for inter-culture. The tractor is designed specially for row-crop work and has a wide range of implements which can be used for intercultural operations.

(2) *Land Master Tractor.*—A two wheeled graden tractor, Land Master, having a stroke, air cooled petrol engine converted to use distillate fuel (powerine) was received from M/s. Willcox Buck Well (India) Pvt. Ltd., for trials. The tractor was tested in the Institute farms for ploughing, hoeing, ridging and drilling. The general performance of the tractor was satisfactory. The tractor however has a low clearance and in its present form cannot be recommended for wide adoption under Indian conditions. The tractor however might be tried for horticultural operations or vegetable plots for market gardening.

(3) *Japanese Tractor.*—A Kubota Tractor, having a 7 B.H.P. single cylinder engine was received from the President's Estate for field tests. The tractor was tested on the farms of the I.A.R.I. and following observations were made :

The tiller was put to haulage test on a compact Kucha road and was observed to ave good traction. The tiller was tested in the field for initial tillage under different soil nditions. The total area tilled during tests was 11 acres. The output was observed to 0.28 acres per hour under hard dry conditions and the average speed of operation was 25 miles per hour. The ditcher when tested behind the rotovator of the tiller was observed produce maximum output when the depth of digging of rotor equals the depth of ditch pened up. The machine was also tested for the haulage test by overloading it to 50% ove the rated load carrying value. The maximum speed on the road was 6 miles per our and it could carry a rated load of 1000 lbs. under most conditions. The belt pulley st was conducted for converting the long stem wheat straw to $\frac{1}{2}$" size Bhoosa with a ammer mill. The performance was satisfactory and the output was 656 lbs. of converted hoosa per hour. The tiller was then tested for field levelling with a wooden plank weighing 37 lbs., 44" long and 12"×2" section. Area of 0.75 acres could be planked per hour. he power unit could also be adopted to drive most types of farm machinery and pumps.

. Experiments on Water Logging Problems at the I.A.R.I.

The investigation into the problem were intensified during the year. The water able data from the 13 I.A.R.I. wells from 1947 to 1957 was plotted to study the seasonal ehaviour of each well over the period and determine the contribution to the problem. urvey of all the major drains of the I.A.R.I. was conducted alongwith reconnaissance urvey of the adjoining areas. Underground water contour maps were also plotted. A reliminary report on the problem has been prepared outlining the probable causes as well s the measures to be adopted for amelioration of the situation.

(1) *Miscellaneous.*—A Conference of agricultural engineers of the States and Representatives of the Industries was held at the I.C.A.R. to discuss the production, distribution nd demonstration of improved and useful agricultural implements. The conference has nade 47 recommendations to the government for production and demonstration of improved agricultural implements. These are under the consideration of the I.C.A.R. as well s the government of India.

(2) *Agricultural Engineers Society of India.*—The above conference had also recommended that an association of workers in the field of Agricultural Engineering to be ponsored by the I.C.A.R. should be set up for development of agricultural engineering and o suggest lines of work.

Under instructions of the I.C.A.R. the memorandum of rules and regulations of the ociety has been prepared and circulated to members of the Agricultural Engineering Committee.

. Intensive Cultivation

The following work has been done in different villages under the Intensive cultivation scheme by this Division during the year under report.

Ploughing by mould board ploughs (Bullocks)	416 acres
Threshing (by olpad thresher)	580 maunds
Ludhiana Thresher	480

Demonstration of a winnowing fan was carried out in the village Nagloi.

Cow dung gas lamps and choolas were maintained in order in four different intensive cultivation villages namely Nagloi, Qamarrudin Nagar, Baprola and Hasthal.

Rabi Compaign.—At the instance of the Ministry of Food & Agriculture the Division carried out the campaign during rabi season in the villages of Jointi, Chattsar, Punjab Khor Jatkhor, Nizampur and Garhi Rindhola of Delhi State. Farmers were advised regarding the use of improved agricultural implements, good disease free seeds, timely sowing etc six demonstration plots one at each of above villages were also laid and four varieties o wheat were sown to demonstrate the advantage of application of manure, line sowing and other cultural practices. Assistance was also given to the various farmers during threshing season and demonstration of olpad threshers was also arranged for them on the farm.

Programme of Work for the year 1959-60

1. Development of a bullock drawn seed-drill.
2. Development of a bullock drawn fertilizer placement machine.
3. Improvement of olpad thresher.
4. Development of a bullock operated leveller.
5. Development of Heating and Lightening appliances for use with Cow dung gas plant.
6. Development of a bullock gear.
7. Testing of agricultural implements and machines for use under local conditions.
8. Study of water logging and rise of water table at I.A.R.I.
9. Study of various modern methods of irrigation and their efficiency in Co-ordination with Division of Agronomy.
10. Study of farm structures, store yards, and rural housing.
11. Study of possibility of improvements of irrigation implements and water lifts.
12. Development of dibbler.
13. Conducting country wide trials of land master L 150 tropical tillers for determining their suitability under Indian conditions.
14. Any other items assigned by the Ministry of Food & Agriculture.

REPORT OF THE ALL INDIA SOIL AND LAND USE SURVEY

(*S. P. Raychaudhuri*)

During the year under report detailed soil survey of the watershed areas of Hirakud, Machkund, Chambal and Bhakra-Nangal dams as well as certain priority areas requested by the State Government from time to time were undertaken in addition to reconnaissance soil survey of certain areas in the States of Kerala, Madras, Mysore and Andhra Pradesh in consultation with the concerned State Government. The areas surveyed under the four soil correlation centres at New Delhi, Nagpur, Calcutta and Bangalore are given below :—

	Detailed survey (acres)	Reconnaissance survey (acres)
1 Alluvial Soil Region, Delhi	1,20,340	5,76,000
2 Black Soil Region, Nagpur	3,68,646	5,496
3 Red and Laterite Soil Region I, Calcutta	72,320	62,720
4 Red and Laterite Soil Region II, Bangalore	57,150	7,69,250
TOTAL	6,18,456	14,13,466
GRAND TOTAL	20,31,922 acres.	

The soil survey reports of the major portions of these areas along with the relevant maps were prepared and the rest has been under preparation. So far, two reports have been published apart from reports of priority areas sent to the State Govts. and other agencies. In these reports soils have been classified and their proper use and capabilities have been indicated *vis-a-vis* their present land use. These survey reports will be very useful in modifying the crop pattern of the area according to its capabilities and also in formulation and execution of programmes for soil conservation.

The cartographic laboratory attached to this scheme was engaged in the preparation of basic soil regions of India and also in the reproduction and printing of the different maps used in the survey reports. Under the scheme of collection and collation of soil survey data in India attached to the Scheme of All India Soil and Land Use Survey, the data on soils of the different States were collected from the various institutions for compilation of the final report.

The details of the progress of work at the different centres are given below :—

I. Alluvial Soil Region, Delhi

This region has taken up soil and land use survey work in the catchment areas of two major river valley projects *viz.*, Bhakra-Nangal in Punjab and Chambal in Rajasthan. Soil and land use survey of some project demonstration areas for soil conservation in Punjab and Himachal Pradesh and also of the Soil Conservation Training, Research and Demonstration Centre at Dehradun have been carried out.

1. *Bhakra Nangal Project*

(a) *Soil survey of Alsed khad sub-catchment.*—About 4500 acres of this sub-catchment were surveyed. The soils are generally light in texture, intermixed with rock fragments at higher elevations. The soil and land use maps of the area were prepared.

(b) *Soil and land use survey of Ghambar sub-catchment, Swarghat.*—An area comprising of 5060 acres were surveyed in this sub-catchment. The soils developed on sandstones, shales and transported material are found to fall under three series and according to land capability can be classified under classes II to VII. The soil survey report along with the soil and land capability maps have been prepared and sent to the Govt. of Himachal Pradesh, the Central Soil Conservation Board, and the Central Water and Power Commission.

(c) *Soil and land use survey of Sirkhad sub-catchment, Samoh.*—Having an area of 7172 acres and receiving an annual rainfall of 1174.2 m.m., this sub-catchment has soils formed from grey sandstone which are noncalcareous and are mainly sand to sandy loam in texture. These soils are susceptible to erosion. Soil and land capability maps for this sub-catchment have been finalised and the report is under preparation.

(d) *Soil and land use survey of Sirkhad sub-catchment, Ghumarwin.*—An area of 6,244 acres have been surveyed in this sub-catchment. Three classes of soils are met with in this area *viz.*, soils developed on sand-stones, slates and of mixed parent material. These soils are generally acidic on the surface layers.

(e) *Soil and land use survey of Sutlej catchment, Pehrwin.*—The Himachal Pradesh Government desired that top priority be given to survey this area of 2741 acres for purposes of developing it into a soil conservation demonstration project. Six series of soils have been established in this area. Soil and land capability maps were supplied to the State Government to pursue the developmental work.

(f) *Soil and land use survey of Sirkhad—Sanwalikhad sub-catchment, Jalwara.*—These two sub-catchments comprise an area of 4534 acres in 35 villages. The same series as observed in Pehrwin area were observed here also.

(g) *Soil and land use survey of Sirkhad sub-catchment.*—As a result of the survey of this area it was found that the soils are mostly derived from sandstone of a noncalcareous nature. Soils are very shallow in about 885 acres while about 1447 acres of land can be classified as waste-land. The preparation of the report is in progress.

(h) *Soil and land use survey of Alikhad sub-catchment, Chandpur.*—This sub-catchment comprising of about 4,000 acres has soils derived from pink shales, mixed parent material and transported materials. The preparation of maps and reports is in progress.

(i) *Soil and land use survey of Ghambar sub-catchment, Saproon.*—The soils of this area are formed either *in situ* or may be transported, shales being the predominent parent material. These are generally heavy and become heavier with depth. Soil type ranges from sandy loam to clay loam. The soil maps are under preparation.

(j) *Soil and land use survey of Rao-khad sub-catchment, Haripur.*—In this area the Punjab Government is starting a soil conservation demonstration project. Examination of soils in the cuttings reveal alternating layers of soil and coarse rock fragments. Classifying the soils into mapping units is in progress.

(k) *Soil and land use survey of the western watershed of the Naina Devi Range, Bassi.*—This area comprises of 33,127 acres of which 6,441 acres are cultivated, 2,949 acres are waste lands and the rest under forests. Taking into consideration the geological formations, five soil complexes have been identified which have further been divided into types based on textural differences.

2. *Chambal Project*

(a) *Soil survey of Ranapratapsagar Dam.*—Reconnaissance soil survey of Ranapratapsagar dam covering about 900 sq. miles was carried out. The soils of this area show close relationship to the parent materials. Both light and heavy textured soils occur in this region. Heavy soils found along the river banks are derived from shales. A large portion of the area, away from the river contains high percentage of sand derived from sandstones.

3. *Soil survey of Borkhandi farm*

This farm, situated in Kotah, has heavy and dark coloured alluvium with abundant lime concretions below. The contours range between 790 and 805. Soils at 805 contour show all the horizons while erosion is observed below this contour line.

4. *Soil survey of non-catchment areas*

(a) *Soil survey of Bainkala watershed, Dehradun.*—The soil survey of the above watershed was undertaken at the request of the Soil Conservation Research, Demonstration and Training centre, Dehra Dun. Out of a total area of 8308 acres, about 3,800 acres are under forests. The soils vary considerably in texture, stoniness etc. These are well drained soils and are classified into 33 units on the basis of differences in morphological characterstics.

(b) *Soil Survey of Hurla area (Kulu Dist.).*—This area was surveyed at the request of the Agricultural Chemist, Punjab. The entire area comprises of 17,280 acres of which 5,328 acres are cultivated and the rest under forests. Soils of the area can be broadly grouped under two categories—sedentary and transported. The important classes recognised are (i) brown soils, (ii) pale brown soils, (iii) light grey soils, (iv) dark grey brown soils and (v) mixed soils. The field work is in progress.

II. Black Soil Region, Nagpur

1. *Soil survey of afforestation areas in Nanded Division, Bombay*

The total area under afforestation scheme which was surveyed is 4,317 acres and comprises of seven blocks in three ranges. The soil survey report indicating recommendations has already been issued. Consisting of Usmanabad Range, Degloor Range and Jintoor Range, the whole area is undulating and highly eroded. As a result of detailed soil survey of this area the soils have been classified mainly according to their depths. It is recommended that the entire area which is at present barren, may be put under forests with the exception of a small area in Varvanti block where plantations may be attempted.

2. *Soil survey of Bijapur district (Mysore State)*

Detailed soil survey of 23,813 acres of gently undulating land was undertaken in this district where Mysore State Government has taken up contour bunding. Three series

of soils *viz.*, Bijapur series I, II and III were recognised which are deep (more than 60") to shallow (less than 10") soils and are reddish brown to dark in colour With proper management to prevent deterioration and run off the soils of first two series are capable of producing good crop yields while the third series of soils are suitable only for shallow-rooted crops of short duration.

3. *Soil survey of military farm at Khamaria (Jabbalpur)*

Detailed soil survey of the military farm at Khamaria, consisting of 657 acre was undertaken. This area has generally deep and clayey soils with few exceptions. As the soils are deep with high water retentive capacity underground hollows are formed at a number of places with the surface soil in tact. Incidence of grazing and indiscriminate cutting of bushes are also severe. The report of this survey indicating proper land use has been sent to the Ministry of Defence for implementing the recommendations.

4. *Soil survey in Amraoti District, Bombay*

An area of 31,710 acres was surveyed in this district. Generally 4 main soil types are met with in this area (a) deep clay, (b) medium clay, (c) shallow clay and (d) very shallow loams. This majority of these soils are very deep and clayey and bunding will have to be carried out with great care. However these areas require careful management including bunding where the soils are shallow and light in texture.

5. *Soil survey in Raisan District, Madhya Pradesh*

The area surveyed is situated in Barchi and Gohargurg tehsils of Raisan district. In this district, eleven villages covering an area of about 23,155 acres, were surveyed. This area, being a broad valley plain and having no prominent topographical variations, is covered by clayey soils varying in depth from shallow to very deep. The former is generally found in severely eroded (now forest areas) and the latter in cultivated areas. Only micro relief reveals any changes in soil phase, the most prominent being erosion phase. Lime appears at places on the surface and in the profile only a *kankar* of varying sizes.

6. *Soil survey of Sapai watershed area in Sundergarh district*

A total area comprising of 1,67,875 acres and 150 villages was surveyed. Each village was surveyed separately and soil maps, land use capability maps prepared. A large part of the area is covered with forests, only limited areas being under grasses. Due to uneven topography of the land the nature of soil type varies widely within short ranges. Six series of soils *viz.*, Sundergarh series I to VI have been recognised. The texture and depth also vary considerably. Some of the profiles show iron concretions at certain depths. As a result of this survey, proper use of land and the extent of cultivable waste lands has been indicated.

7. *Soil survey of Ib river catchment in Sundergarh district*

This area is in continuation of the Sapai area and comprises of 52 villages with an area of 94,773 acres. As a result of the survey it has been established, that the soil types are similar to those of Sapai area. The preparation of maps and reports is in progress.

8. *Survey of Mand watershed in Raigarh District, Madhya Pradesh*

The area under survey *viz.*, 8,793 acres is undulating and is about 700 ft. above m.s.l. During floods large areas are affected and the lands on the banks are damaged due to deposition of sand. The river basin is being silted up and getting shallower at many places.

Land slides are common. Two major series of soils are recognised on the basis of profile characteristics *i.e.* with and without lime *kankars*. The soil maps of these areas are under preparation.

III. Red and Laterite Soil Region I, Calcutta

1. *Soil and land use survey in Machkund and Padwa police stations in Orissa (Machkund project)*

The catchment area of Machkund river is located on the western slope of the Eastern Ghat at an elevation between 2,000 and 3,000 feet above m.s.l. with an annual rainfall of about 72". In the area of about 50,000 acres surveyed so far, the soils range from shallow gravelly soils with rock out-growth to very deep alluvial soils with very poor drainage. Nine series of soils have been recognised in the area. As a common feature of all soils, iron concretions are observed which generally increase with depth. The soil map, present land use map and land use capability maps for the area have been prepared. According to land use capability, the area falls under classes II to VII.

2. *Soil and land use survey in Kanksa police station, West Bengal (D. V. C. area)*

Reconnaissance soil survey of this area has been completed. The climate is characterised by an annual rainfall of about 60" with a mean annual temperature of 68° F. Gondwana rocks, shales, sandstone and older alluvium form the geologic complex of the area. The soils of this area are found to fall under eight series depending upon the horizon differences. Generally the soils are deep with low to high rate of permeability. As per land use capability the lands can be classified into classes I to VI.

3. *Soil and land use survey in the refugee rehabilitation areas in Midnapore, West Bengal*

About 9,600 acres of land were surveyed in different parts of this district. In the areas surveyed, lateritic masses and gravels are observed in the high land areas in the subsoils which are sublaid by feldspathic sand and clays. Two series of soils are recognised in this area. These soils are generally yellowish red to reddish brown in colour and are sandy with iron concretions. Laterite beds are observed at varying depths. Classified according to their capabilities these fall under classes IV and V.

4. *Soil and land use survey in Pipli police station, Orissa (Mahanadi project area)*

This police station forms the southern portion of the Mahanadi project area and has an area of about 5,120 acres. The area mainly consists of flat and nearly level alluvial fans locally called as "doab" with occasional low lying marshy areas or "jheels". The soils of the areas has been classified under seven series. They range from heavy poorly drained clays of the marshy low land to grey coloured sandy loams of the high land areas. Ferruginous concretions are met with in almost all the areas. These soils can be classified under classes II to VI according to their land use capability. The report along with the soil map and land use maps has been prepared.

5. *Soil survey in Mal police station, West Bengal (proposed Hahaipata tea estate)*

The area surveyed is situated in "Terai", a humid tropical region of West Bengal and is situated at a height of about 600 feet above m.s.l. with uneven topography. The area may be grouped into four broad physiographic regions (a) elongated and oval plateaus, (b) flat and nearly level uplands, (c) gently rolling to level upland terraces in between flat lands and plateaus and (d) low lands.

Following the physiographic divisions four kinds of soils have been met with in the area surveyed *viz.*, till soils, flat and level upland soils, upland terrace soils and lowland soils. The report along with the maps has been prepared and issued with particular reference to the suitability of these soils for tea growing.

6. Soil survey in Passighat area, NEFA.

Located in a rainfall of about 230" annually this area is undulated and generally covered with forests. In the area surveyed five series of soils have been identified and mapped. The soils range from deep well drained alluviums mixed with boulder to shallow soils on hill slopes. These are generally red in colour. The report along with the maps of the area surveyed is under preparation.

IV. Red and Laterite Soil Region II, Bangalore

Field surveys involving detailed and reconnaissance surveys for land use classification have been carried out in (i) Madras, (ii) Kerala and (iii) Andhra Pradesh.

1. Madras State

Detailed soil survey of Ootacamund town and rural areas.—A detailed soil survey of Ootacamund town and rural areas in Nilgiris district was undertaken. Soil data, monoliths of master profiles, agricultural information etc. were collected in detail. As a result of this survey two soil series *viz.*, Ootacamund soil series I and II have been established of which the former occupies extensive area with the exception of valley bottoms and gently sloping hill flanks. These soils are developed from materials weathered from igneous and metamorphic rocks belonging to the general group of gneisses. They are deep soils having dark brown colour on the surface layers and are of utmost utility to agriculture and forestry. Soils belonging to Ootacamund series II are developed on colluvial valley fillings under swamp herb vegetation and have poor drainage.

2. Kerala State

(a) *Detailed soil survey of Kakkad valley—Food production area—3328 acres.*—This area was surveyed out of the 24,000 acres of food production area taken up by the State Government for soil conservation. Four district series of soils have been established based on profile characteristics *viz.*: Soil series I (Travancore), II, III and IV. Half the area under soil series I is abundant in rock pieces, boulders and stones and hence this series has been sub-divided into two phases. Soils under series II and III are comparatively deep soils while soils under series IV are alluvial beds of rivers and streams. Based on depth of soil, slope characters and extent of erosion the soils of this area have been classified into land capability groups II to VII.

(b) *Reconnaissance survey of Payyannoor C. D. Block.*—A reconnaissance soil survey was carried out in Payyannoor C. D. Block in Cannanore district covering an area 1,28,200 acres. Three series of soils have been recognised and described, of which one is alluvium. The report along with the relevent maps have been prepared.

(c) *Detailed soil survey of Vayakkara village—Payyannoor.*—A detailed soil survey of about 5,000 acres in the villages covering Vayakkara and neighbouring areas has been completed. The soils of this area one found to fall under the same series as those identified in the reconnaissance survey. Land use classification of these area has been done.

(d) *Reconnaissance and detailed soil surveys in Nedumangad taluk, Trivandrum district.*—A reconnaissance soil survey of this taluk having an area of about 2,80,000 acres was carried out. Four series of soils of which one is an alluvium have been described. In this area detailed soil survey was carried out for about 4,600 acres where forest lands have been cleared and brought under cultivation and where conservation measures are proposed to be adopted. The soils of these areas have been mapped on 16″ = 1 mile scale and land classification made.

3. *Andhra State*

A reconnaissance survey of Anantpur taluk covering an area of about 3,20,000 acres was carried out. In this area, red and black soils occur side by side. Six soils series which are identical to those described in Chittoor district, are found to occur here. In addition an alluvium and a black soil series have also been described.

Detailed soil survey of about 13,000 acres in this taluk representing areas where soil conservation work can be taken up, has been carried out. Land use classification maps were drawn up for this area.

A reconnaissance survey of Chandragiri taluk in Chittoor district covering an area of about 3,51,000 acres has been carried out. About 6,000 acres were covered by detailed soil survey near Rayachoti town. The soils have been classified and land use classification maps prepared.

V. Cartography

A procedure have been laid for colour separation mapping and for symbolisation of soil survey data. Tints have been laid down for topographic maps. Specification of type founts for lettering soil maps on 1″=4 miles scale has been determined. A study of the basic soil regions of India was made.

Thirteen hundred and thirteen maps have been reproduced.

VI. Scheme for Collection and Collation of Soil Survey Data in India

In this Scheme which functions at Delhi and Kanpur, the published data on soil and agronomic work in India since 1946 were collected. The unpublished data available in the different agricultural institutions, since 1946 have also been collected. These data are being compiled for the purpose of revising the Final Report of All India Soil Survey Scheme.

Programme of work for 1959-60

I. *Alluvial Soil Region, New Delhi* :

1. Soil and land use survey in the catchment area of Bhakra-Nangal priority areas.
2. Soil and Land use survey in the catchment area of Chambal project priority areas.
3. Soil survey in Ludhiana, Hissar, Kulu and Hoshiarpur districts of the Punjab.
4. Soil survey in Dungarpur and other priority area of Rajasthan.
5. (a) Continuation of soil correlation and interpretation of work of the region.
   (b) Survey and mapping of Delhi State.

II. *Black soil Region, Nagpur* :

Party No.	Name of Soil Survey Asstt.	Period	Description of area to be surveyed	Total area to be covered
1	2	3	4	5
				Acres
1	Shri V. S. Deshmuck .	Oct. '59 to June 1960	Sub-watershed of San Banda Jor, Ib watershed under Mahanadi Catchment (Sundargarh Dt., Orissa State).	40,000
2	„ R. R. Biswas . .	Do.	Sub-watershed or Banda Jor, Ib Watershed under Mahanadi Cathment (Sundargarh Dt., Orissa State).	40,000
3	„ P. M. Jawade . .	Do.	Sub-watershed of During Jor, Ib watershed, under Mahanadi Catchment (Sundargarh District, Orissa State).	40,000
4	„ J. S. Lamdhade .	Do.	Sub-watershed of Tunga Nadi Ib watershed under Mahandi Catchment (Sundargarh Dt., Orissa State).	
5	„ S. G. Pande .	Do.	Do.	40,000
6	„ N. J. Mudholkar .	Oct. '59 to Feb., 1960	Sub-watershed of Ghoira Nadi Ib watershed, under Mahanadi Catchment (Sundargarh Dt., Orissa State).	25,000
7	„ P. G. Shanware .	Oct. '59 to Feb., 1960	Sub-watershed of Ghoira Nadi Ib watershed under Mahanadi Catchment (Sundargarh Dt., Orissa State).	25,000
		March-June, 1960	Bari and adjoining area in Raisen Dt., M. P. (Bhopal).	30,000
8	„ R. J. Landey .	Octo. '59 to June, 1960	Dharmjoygarh and Ghargoda areas in Mand watershed Raigarh Dist., M.P.	40,000
9	„ T. M. Deshmukh .	Do.	Do.	40,000
10	„ Rajaram Shankar .	Sept. to Nov. 59	Bijapur taluka in Bijapur District, Mysore State.	10,000
		Dec. '59 to June, 1960	Bapatla taluka in Guntur Dt., Andhra State.	30,000
11	„ S. B. Deshpande .	Sept. to Nov.'59	Bijapur taluka in Bijapur District, Mysore State.	10,000
		Dec. '59 to June, 1960	Bapatla taluka in Guntur Dt., Andhra State.	30,000
12	„ A. S. Gowaikar .	Oct. '59 to June, 1960	Amraoti & Yeotomal District, Bombay State.	40,000
13	„ G. H. Sapate . .	Do.	Do.	40,000

II. *Red and Laterite Soil Region-*1, *Calcutta* :

Party	Name of S.S. Asstt.	Area of work	Area to be covered in acres.		Total in the period
					Acres
A	Shri K. C. Mazumder .	Rourkela, Orissa State .	Aug. to Dec.	21,000	..
B	,, G. P. Biswas. .	Refugee Rehabilitation area in Midnapur.	Aug. to Sep.	33,000	54,000
		Kosi Catchment area .	Oct. to June,	22,000	..
		Development Blocks in Tripura State.	Feb. to June,	28,000	54,000
C	,, H. S. Iyer . .	Jalapur, Machkund .	Oct. to June,	54,000	54,000
D	,, P. K. Banerjee .	Rourkela, Orissa. .	Aug. to Sept.	3,000	..
		Padwa, Machkund .	Oct. to June,	51,000	54,000
E	,, M. V. Chayanula .	Rourkela, Orissa .	Aug. to Sep.	3,000	..
		Araku, Machkund .	Oct. to June	51,000	54,000

Total area to be surveyed will be stepped up suitably at an effective average of 4,000 acres per new assistant per working month, as and when new Soil Survey Asstts. are appointed.

IV. *Red and Laterite Soils Region II, Bangalore* :

Party I . *Madras* . . . Nilgiris District—Ootacamund Taluk.

(a) Completion of reconnaissance Survey of Ootacamund Taluk—50,000 acres.

(b) Completion of detailed Survey of Nanjanad, Ithalar and and Melkundah areas —20,000 acres.

(c) Completion of mapping of Ootacamund Taluk, Ootacamund town and rural areas where field work was completed.

Party II . *Mysore* . . . Mandya District—

(a) Completion of reconnaissance survey of Malavalli Taluk—75,000 acres.

(b) Completion of detailed survey of 15 villages in Malavalli Taluk where virginia tobacco is grown—10,000 acres.

(c) Detailed survey of soil conservation areas in Chittaldrug Dist.—10,000 acres.

(d) Completion of the reports of Honnali, Shikaripur and Sorab Taluks together with their maps.

Party III *Andhra* . . . Anantapur Taluk—Kalyan Drug Taluk.

(a) Detailed survey of soil conservation areas—10,000 acres.

Party IV *Andhra* . . . Hyderabad—

(a) Detailed survey of soil conservation areas near Hyderabad–20,000 acres.

Party V . *Kerala* . . . Trichur District—

(a) Reconnaissance survey of Chalakundy Taluk—50,000 acres.

(b) Detailed survey of soil conservation areas—10,000 acres.

(c) Completion of the reports of Payyannur and Nedumangad areas.

V. Cartographic Laboratory.

1. Standardisation of densities of colour separation negatives for reproduction of various soil groups.
2. Laying down specifications of map lettering for large scale maps.
3. Determination of Basic Soil Regions of India (Major units) and their geography.
4. Standardisation of a rapid method of soil survey from aerial photographs.
5. Standardisation of a procedure for the preparation of a map manuscript.
6. Reproduction of various types of base maps and soil maps for the different soil regions and states.
7. Assembly of the cartographic camera, and the coordinate plotter.
8. Examination of soil survey data and preparation of map manuscripts for reproduction.

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3.	Bhatacharjee, J. . . .	Land utilisation survey and Land use planning in a typical latents area in West Bengal—Ind. August. vt., 2/ (2)/ 1958.
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7.	S. P. Gupta . . .	Fluctuation of available phosphate in Ganga low-land soil as affected by different manurial treatments.—J. Indian S. of Soil Science Vol. 6, No 4, 1958.

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11. Satyanarayana, K. V. S. & Rawat M. S. 1958 Survey and classification of land in chopra village, Delhi State—I.J. of Soil and Water Conservation in India. I. 18.

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Satyanarayana, K. V. S. . .	1959	Utility of soil and land use surveys with the specia reference to Bhakra-Nangal Dam Catchmen area Seminar on recent advances in Agronomy an Soil Science and their application to increase crop production, Simla.
Satyanarayana, K. V. S. & Rao Y. N.		Phosphate fixation by laterites & associated soil of West Coast of India.
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		Ditto.
Satyanarayana, K. V. S. & Dhir R. P. & Rao Y. N.		A colorimetric method for the determination of cation exchange capacity of soils and clays.
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12. Shende, N. K. and Sen S. .		Phosphate manuring of legumes, manuring of guar (*Cyamopsis tetragonoloba*) with phosphate and micronutrients and its effect on physical and chemical properties of the soils. Ind. J. Agron. 3 p. 90).

V. TRAINING OF STUDENTS AND RESEARCH WORKERS DURING 1958.

(*a*) Students awarded the Post graduate Diploma

Division of Agronomy

1.	Shri A. I. Thomas	Studies on the manuring of tobacco.
2.	,, A. S. Patel	Studies on the effect of farm yard manure and ammonium sulphate at different levels on wheat.
3.	,, G. M. Karemore	Control of weeds in peas by chemical and cultural methods.
4.	,, L. N. Chakravarty	The inter-relation of delta and the depth of irrigation and the level of nitrogen on the potato crop.
5.	,, M. D. Morey	Studies on the after effects of phosphate manured berseem on wheat.
6.	,, M. L. Bhendia	Relative efficiency of nitrogenous fertilizers for wheat production.
7.	,, M. M. P. Shrivastava	Differential response of wheat varieties to fertilization with nitrogen, phosphate and potash and their combinations.
8.	,, M. P. Shah	Role of Hubam clover as a mixed crop in wheat-maize rotation.
9.	,, N. A. Awatramani	Effect of varying soil moisture regions and method of irrigation in relation to nitrogen on the tobacco crop (*Nicotiana rustica*).
10.	,, P. K. Chatterjee	Response to sources and levels of nitrogen in combination with different doses of phosphate on wheat.
11.	,, R. S. P. Srivastava	Effect of application of different doses of nitrogen, phosphate and molybdenum on cauliflower.
12.	,, S. L. Kanoje	Effect of varying doses of nitrogen and phosphate and different time of application of nitrogen on tomato.
13.	,, N. N. Sahai	Study of the response of *Boro* Rice to various types and levels of nitrogen in combination with phospate and potash.
14.	,, A. R. Belsare	Agricultural extension through rural leadership.
15.	,, Balwant Singh Bhatt.	Agricultural extension through rural youth.
16.	,, C. S. S. Rao.	Evaluation of extension methods for successful introduction of improved farming practices.
17.	,, M. S. Sahoo	Effectiveness of certain extension techniques in relation to the socio-economic status of farmers.
18.	,, R. L. Gautum	Extension techniques employed to develop cooperation amongst cultivators.
19.	,, K. K. Saxena	Efficiency of the V. L. W. as affected by different levels of academic standards and the influence of rural and urban background.
20.	,, P. N. Jakate	Relative effectiveness of extension techniques for success of soil and water conservation programme.

21.	Shri Manmohan Sawhney . .	Investigation into extension methods of introducing improved agricultural implements.
22.	,, B. Mandal	Inter-relationship of cultivation treatment levels of nitrogen and irrigation interval on sugarcane.
23.	,, K. K. Murthy . . .	Effect of varying depth of cultivation with doses of nitrogen and the methods of application on the yield of cotton.
24.	,, J. Pattanaik	Control of weeds in cotton by chemical and cultural methods.
25.	,, G. S. Grewal . . .	The influence of water soluble sodium silicate, F. V. M. and castor cake on soil aggregation and their indirect effect on maize crop.
26.	,, K. R. Panchbhai . . .	Study of response of some *indica and Japonica* types of rice to various N and P levels in the boro crop season.
27.	,, N. Sadanandan . . .	Effect of split dose application of nitrogenous fertilizers on the yield and other organic characters of rice (*Oryza sativa* L.).
28.	,, P. K. Chanda . . .	Study of response of Indica varieties of Rice (*Oryza Satival*) to different levels of soil fertility.

DIVISION OF BOTANY

1.	Shri A. P. Choudhari . . .	Studies in induced tetraploids of berseem and *senji*.
2.	,, R. G. Thakare . . .	X-ray irradiation studies in linseed.
3.	,, N. Meherchandani . .	Studies on *Solanum rybinii*.
4.	,, O. P. Makhija . . .	Studies on the mode of inheritance of seedling reaction to different races of the three wheat rusts in some intervarietal crosses of *T. aestivum*.
5.	,, A. P. Ekbote . . .	Economic evaluation of some of the Russian introductions of *G. hirsutum* L.
6.	,, P. K. Patel	Economic evaluation of some of the American introductions of *G. hirsutum* L.
7.	,, G. B. Pattanaik . . .	Assessment of breeding value of certain Coimbatore canes.
8.	,, T. D. Jha	Genetic studies in barley—Inheritance of pigmentation and certain other characters in *vulgare* × *distichon* crosses.
9.	,, N. Madhavan Nair . .	Studies on the origin of cultivated Rice—Cytogenetical studies of the related species and their hybrids.
10.	,, N. R. Nair	Genetics of Rice—the inheritance of hairiners, clusfering, beaked habit and anthocyanin pigmentation, and the interrelationship of the genes governing these characters.
11.	,, G. A. Katwe . . .	Breeding rice strains suitable for different levels of soil fertility—study of the F4 generation of *Japonica* × *indica* hybrids.
12.	,, K K Jain	A comparative study of the diploid and *autotetra Ploid toria* special reference to the estimation of some genetic constants as aids to selection.

13.	Shri M. Rama Rao . . .	Study of genetic variability in some varieties of *G. hirsutum* with regard to neppiness.
14.	,, G. R. K. Sastry . . .	Mutation studies on cotton and wheat.
15.	,, K. S. Parmar . . .	Studies on the combining ability in some inter-varieta crosses of *Triticum aestivum.*
16.	,, M. P. Alexander . . .	Studies on induced polyploidy in some ornamental plants.
17.	,, A. K. Bose	Studies on phenotypic and cytological effects of irradiation in ornamental plants.
18.	,, S. A. Dadlani (Departmental candidate)	Embryological investigations in some species and species crosses in the genus *sesamum.*

DIVISION OF SOIL SCIENCE AND AGRICULTURE CHEMISTRY

1.	,, B. N. Acharya . . .	Fertility status of some acid soils in relation to availability of nutrients from some nitrogenous fertilizers.
2.	,, P. P. Barooah . . .	Studies on *Azotobacter* in acid soils.
3.	,, M. V. Chayanulu . .	The *Rhizosphere* effects on micro-organism.
4.	,, S. K. De Datta . . .	Soil and fertilizer phosphorus used by legumes, effect of organic matter, silicates and chelates and study of their residual effects.
5.	,, P. L. Deshmukh . . .	Pedochemical characteristics of some alluvial soils in the Ganga-Jamuna doab.
6.	,, S. B. Deshpande . . .	Foliar application of nutrients to barley.
7.	,, H. Eshwarappa . . .	Studies on the organic phosphorus of red and black soils.
8.	,, S. P. Gawande . . .	Relation of slope to the formation of black soil from basalt rock.
9.	,, V. Gopalaswamy . . .	Studies on fertility status of peat and marshy soil.
10.	,, Gurcharan Singh . . .	Soil genesis from alluvial parent materials and relationship of soil type to land use.
11.	,, A. R. Kalbande . . .	Evaluation of soil tests correlation at different doses of nitrogen applied to wheat in Delhi State soils.
12.	,, M. V. Kanzaria . . .	Study of the effect of continuous manuring and cropping on soil fertility in Pusa—permanent manural series experiments.
13.	,, R. L. Karale . . .	Effect of varying rainfall on the soil development on basalt rock in Bombay Deccan.
14.	,, S. S. K. Nanda . . .	Pedochemical characteristics of some red and laterite soils.
15.	,, T. V. B. Pillay . . .	Physico chemical factors in the utilization of acid soils of India including the Kari soils.
16.	,, S. Prasad	Pedogenic studies on diverse soil types occurring in close locality.
17.	,, C. K. Rajgopal . . .	Studies on phosphate fixation and availability in some red and laterite soils.

18.	Shri B. K. Sinha	Studies on the nature of saline and *alkaline* soil in south west Uttar Pradesh.
19.	,, V. K. Saolapurkar	Correlation of soil tests with response of wheat in Delhi soils.
20.	,, D. Subba Rao	Microelement status (total and available) of some Indian soils with particular reference to the growth of tobacco.
21.	,, S. M. Umar	Soil sampling in relation to crop response and nutrient availability.
22.	,, S. Venkatachalam	Study of some soil factors determining the safe utilization of irrigation water.
23.	,, K. K. Vyas	Phosphorus fixation, availability and uptake by wheat and paddy under different moisture and organic matter levels and the study of their residual effect.

Division of Entomology

1.	Shri G. G. Kundu	Studies in resistance to some of insecticides by beneficial insects (parasites).
2.	,, N. R. Ananthakrishnan	Effect of post-treatment temperature on insect susceptibility to insecticidal films.
3.	,, M. N. Borle	Relative toxicity of different insecticidal films to the just-hatched larvae of pink boll worm (*Platyedra gossypiella* Saund.) of cotton.
4.	,, S. Afzarul Hakk	Systematic studies on the Indian Tingoidea.
5.	,, P. B. Suchak	Comparative efficacy of insectieidal sprays against locust hoppers (*Locusta migratoria* Linnaeus and *Schistocerca gregaria* Forskal).
6.	,, G. Rout	Relative Efficacy of some fumigants against *Tribolium castaneum* Hbst.
7.	Miss Nandini S. Khot	Taxonomy, bionomics and biology of entomophagous mites.
8.	Shri K. Gopinath	Effect of temperature and humidity on the reproductive potential of *Apanteles angaleti* Mues. (Vipionidae Hymenoptera).
9.	,, J. P. Sahu	Relative toxicity of insecticidal films to the just-hatched larvae of sugarcane borer (*Chilortea infuscatellus* Snell. *Scirpophaga nivella* Fabr.)
10.	,, R. Vishwanathan	The Development of pink bollworm, *Platyedra gossypiella* Saunders in different temperature and humidity conditions.
11.	,, M. A. Holkar	Taxonomic studies on Indian Fulgoroidea (Homoptera)

Division of Mycology and plant Pathology

1.	Shri P. K. Sen Gupta	Further studies on the biological activity of the active principle secreted by *B. subtilis* in soil and plants—(Effect of molasses etc.).
2.	,, C. Laxminarayana	Further studies on sugarcane rust in India.

3.	Shri V. Rajendran . . .	Infection of wheat seedlings of different varieties with powdery mildew—Factors affecting infection.
4.	,, B. C. Dave	Studies on Bacteriophage of *Xanthomonas citri* the citrus canker organism.
5.	,, B. B. Bhombe . . .	Investigations on the seed-borne disease of vegetables.
6.	,, S. S. Quiniones . . .	Eaxonomic studies on some species of *Colletotrichum.*
7.	,, B. K. Chandersekhar . .	Movement of sannhemp mosaic virus in sannhemp.
8.	,, H. O. Agarwal . . .	Studies on the factors affecting production of perfect stage of *C. Falcatum* Went.

(b) Students admitted to the —Ph. D course

Division of Agronomy

1. Shri C. S. S. Rao
2. ,, C. R. K. Prashar
3. ,, D. N. Puri
4. ,, M. M. P. Srivastava
5. ,, M. M. Sawhney
6. ,, N. N. Sharma
7. ,, O. P. Gupta
8. ,, Pran Nath
9. ,, Sheoji Pande

Division of Botany

1. Shri M. V. Prabhakar Rao
2. ,, C. Bhatia
3. ,, Joginder Singh
4. Miss S. K. Nirula
5. Shri K. S. Murty
6. ,, S. L. Basak
7. ,, Ved Pal Gupta
8. ,, P. K. Ramiah
9. ,, K. L. Shahare

Division of Soil Science and Agricultural Chemistry

1. Shri P. P. Barooah
2. ,, K. K. Vyas
3. ,, S. P. Gawande
4. ,, R. L. Karale
5. ,, A. R. Kalbande
6. ,, Rattan Singh
7. ,, N. N. Goswami
8. ,, A. Sankaran
9. ,, P. M. Tamboli

Division of Entomology

1. Shri M. L. Purohit
2. ,, D. S. Kathuria
3. ,, P. V. Ranga Rao
4. ,, S. K. Bhatia
5. ,, S. A. Hakk
6. ,, R. Vishwanathan
7. ,, P. C. Nigam
8. Miss N. S. Khot

Division of Mycology and Plant Pathology

1. Shri M. S. Manocha
2. ,, B. Ganguli
3. ,, M. L. Sahni
4. ,, R. N. Prasad
5. ,, Pritam Singh
6. ,, K. S. M. Sastry
7. ,, Pritam Singh Sachdeva
8. ,, C. S. K. Moorty
9. Miss Om Kumari Ghei.

Division of Horticulture

1. Shri S. S. Randhawa
2. ,, S. N. Singh
3. ,, R. B. Sinha

(*c*) *Students admitted to the M. Sc. course*

Division of Agronomy

1. Shri B. C. Barbara
2. ,, B. C. Hota
3. ,, B. K. De
4. ,, B. R. Deshmukh
5. ,, B. S. Chavan
6. ,, D. Kulkarni
7. ,, K. C. Das
8. ,, G. N. Kulkarni
9. ,, M. N. Banerjee
10. ,, R. N. Misra
11. ,, R. P. Soni
12. ,, R. J. Bhosale
13. ,, S. A. Khureshi
14. ,, S. Chattopadhyay
15. ,, S. K. Dubey

16. ,, S. Krishnamurthi
17. ,, S. N. Chatopadhyay
18. ,, S. P. Bose
19. ,, V. S. Sankaran Potti

Division of Botany

1. Shri Harnek Singh Randev
2. ,, Jai Bhagwan Choudhury
3. ,, Akshay Kumar Gupta
4. ,, Rajender Bir Kumar Bammi
5. ,, Jagdish Bihari Lal Mathur
6. ,, Satanjiw Das Sharma
7. ,, Rajendra Narayan Misra
8. ,, S. S. Sindagi
9. ,, Gurcharan Singh
10. ,, P. N. C. Pillay
11. ,, Sekhar Chandra Sur
12. ,, Ram Das Bansal
13. ,, P. K. Mohan Rao
14. ,, Devender Kumar Nanda
15. ,, Ram Nath Kaw
16. ,, P. K. Narayan
17. ,, Narayan Singh Sisodia
18. ,, P. D. Hukeri
19. ,, Dhan Raj Jain
20. ,, K. Ramiah
21. ,, K. B. Desai
22. ,, H. N. Sonone
23. ,, Bhup Dev Bhardwaj

Division of Soil Science and Chemistry

1. Shri S. C. Chakravarthy
2. ,, S. K. Gupta
3. ,, A. K. Bandopadhyaya
4. ,, N. P. Sinha
5. ,, N. C. Debnath
6. ,, P. K. Sarkar
7. ,, K. M. Jacob
8. ,, B. Dutt
9. ,, J. V. Ojha
10. ,, H. K. Mehra
11. ,, G. Padmanabhan
12. ,, A. S. Hadimani
13. ,, R. K. Gambir

14. ,, P. S. A. Reddy
15. ,, K. P. Goswami
16. ,, B. M. Ramalingu
17. ,, S. M. Kondapurkar
18. ,, G. P. Khurana
19. ,, K. T. Mahajan
20. Miss S. Viravaidhya

Division of Entomology

1. Shri G. K. Garish
2. ,, A. K. Kolya
3. ,, G. K. Punj
4. ,, Baby Zachariah
5. ,, C. L. Kaul
6. ,, G. R. V. Gowda
7. ,, R. K. Agarwal
8. ,, M. Haque
9. ,, P. B. Dhar
10. ,, S. M. Peeran
11. Miss G. P. Vani

Division of Mycology and Plant Pathology

1. Shri G. S. Dave
2. ,, S. K. Batra
3. ,, V. R. Rao
4. ,, Islam Din
5. ,, H. C. Sharma
6. ,, A. Pandrangi
7. ,, K. O. Nyako

Division of Horticulture

1. Shri O. P. Sehgal
2. ,, R. L. Sharma
3. ,, B. B. Sharma
4. ,, H. C. Sharma
5. ,, C. P. A. Iyer
6. ,, P. S. Godara
7. ,, S. S. Choudhury
8. ,, V. K. Damodaran
9. ,, S. K. Chopra
10. ,, J. D. Shakya
11. ,, Imtiaz Rasul
12. ,, H. S. Sangha
13. ,, A. V. Patil
14. ,, G. C. Joshi

(*d*) *Students admitted to the 3 month course on the use of radio-active isotopes in agriculture*

1. Shri K. M. Bojappa
2. ,, L. V. Vaidyanathan
3. ,, Niranjan Maherchandani
4. ,, R. N. Mukherjee
5. ,, M. S. Chatrath

(*e*) *Short course training to the officers of Vigyan Mandir Scheme*

1. Shri P. R. Sen Gupta
2. ,, G. L. Sumbaly
3. ,, S. N. Patnaik
4. ,, V. Ravi Kumar
5. ,, S. S. K. Nanda
6. ,, B. Behra

(*f*) *Short course training to maize breeders in maize breeding and seed production*

1. Shri S. N. Ghosh
2. ,, R. Narayana Rao
3. ,, M. Sankara Rao
4. ,, G. Kamaswera Rao

(*g*) *Short course training in analytical work*

1. Shri Mohd. Salamat Ullah
2. ,, D. L. Sharma
3. ,, M. A. Razak Khan
4. ,, M. Badri Narayan Rao
5. Miss Mira Ghosh

(*h*) *Refresher course in geneties and plant breeding*

1. Dr. U. N. Verma
2. Shri R. C. Shah
3. ,, A. T. Abraham
4. ,, M. N. Khare
5. ,, P. S. Srivastava
6. Dr. R. S. Deshpande
7. ,, D. K. Tiwari
8. ,, A. Rathore
9. ,, S.K. Singh Gaur
10. ,, M. S. Lal
11. ,, D. C. Beohar
12. ,, S. K. Chandrasekerah
13. ,, H. K. Mohanty
14. ,, Gursuran Singh
15. ,, T. C. Shukla

16. ,, R. S. Vasudeva
17. ,, R. N. Muralia
18. ,, J. S. Dhaliwal
19. ,, H. N. Mehrotra
20. ,, S. M. Gandhi
21. ,, K. B. Trehan
22. ,, G. S. Murty
23. ,, K. Das

(i) Short course training arranged in different Divisions

1. Shri G. S. Agarwal . . . . Chemistry
2. Dr. P. Shanta . . . . Mycology & Plant Pathology
3. Shri H. S. Douley . . Statistics

(j) Honorary research workers

1. Shri S. Bhaskaran . . . . Botany
2. ,, P. R. Jagdish . . . Botany
3. ,, C. Nambiar . . . . Botany

VI. ABSTRACT OF THESES SUBMITTED BY THE POST GRADUATE STUDENTS (1958)

Division of Agronomy

1. *Chanda, P. K., Study of response of* indica *varieties of rice* (Oryza sativa *L.*) *to different levels of soil fertility*

At the Central Rice Research Institute, Cuttack the differential response of 24 rice varieties (*indica*) to 4 levels of soil fertility was studied during the main season of 1957. The fertilizer levels tried were 0, 30, 60 and 90 lb. N/acre applied in 3 equal split doses with green manuring as basal dressing. It was observed that an increase in the yield of green and straw was obtained for each successive increase in nitrogen level upto 60 lb. N/acre beyond which the yield was found to be depressing. Out of 24 varieties, 18 showed a quadratic and three linear types of response. In the remaining 3 varieties response was not significant. However, the differential response of varieties to levels of nitrogen was not found to be significant.

2. *Gurmel Singh Grewal, the influence of water soluble sodium silicate, F.Y.M. and castor cake on soil aggregation and their indirect effect on maize crop*

Effect of water soluble sodium silicate at 2 levels (0.15 and 0.3 per cent silicate on dry soil basis) was studied on the yield of maize, when applied alone or in conjunction with 5 and 10 tons of farmyard manure or/and 30 and 60 lb. N/acre in the form of castor cake. It was observed that application of water soluble sodium silicate increased soil aggregation water holding capacity but had no effect on maize yield. Application of farm yard manure @ 5 tons per acre gave higher response than 10 tons. This was mainly due to increased soil aggregation. Castor cake 60 lb. N/acre gave higher yield than 30 lb. N/acre applied in the same form.

3. *Patel, A. S., Studies on the effect of farmyard manure and ammonium sulphate at different levels on wheat*

To study the effect of doses of farmyard manure (0, 40, 80 and 120 lb. N/acre) either applied alone or in combination with 20, 40 and 60 lb. N/acre in the form of ammonium sulphate, an experiment was conducted on wheat during rabi 1957-58. It was observed that the response to doses of nitrogen applied in the form of farmyard manure was linear while to ammonium sulphate it was quadratic. The optimum dose of ammonium sulphate worked out to be 34 lb. N/acre. Recovery of nitrogen from ammonium sulphate was 32 to 45% while from farmyard manure either applied alone or in combination with inorganic nitrogen it was 15-23%. At 80 lb. nitrogen N/acre farmyard manure was found to be 50% as efficient as ammonium sulphate. Addition of ammonium sulphate to farmyard manure was not found to be beneficial.

4. *Shah, M. P., Role of Hubam clover as a mixed crop in wheat maize rotation*

To study the effect of Hubam clover as a mixed crop in wheat for fodder and/or green manure in wheat-maize rotation, an experiment was carried out with *kharif*-fallow sunnhemp green manure, 40 lb. N/acre to wheat and/or maize and 80 lb. P_2O_5 per acre to Hubam clover. It was observed that application of phosphorus increased fodder yield and green matter of Hubam clover. Application of 40 lb. N/acre to maize and wheat increased the profit by more than 100% compared to fallow-wheat. Application of nitrogen to wheat was second and Hubam clover in association with phosphorus for green manure was third in order of profits.

5. *Bhendia, M. L., Relative efficiency of nitrogenous fertilizers for wheat production*

To study the relative efficiency of five commercial nitrogenous fertilizers *viz.* ammonium sulphate, ammonium sulphate nitrate, ammonium chloride, ammonium nitrate and urea at the levels of 20, 40 and 60 lb. N per acre for wheat production, an experiment was conducted during rabi 1957. It was observed that all the five nitrogenous fertilizers proved to be good carriers of nitrogen as the responses with them were almost equal. Wheat yield increased with doses of nitrogen with linear response. Application of 20 lb. P_2O_5 per acre as basal dressing had no appreciable effect on wheat.

6. *Chakravarty, L. N., Inter-relation of delta and the depth of irrigation and the level of nitrogen on the potato crop*

During the study of inter-relationship of delta and depth of irrigation and levels of nitrogen on potato crop it was observed that the highest yield was obtained with the application of 36 ″ of water with shallow or medium depth of irrigation. 3 ″ depth of water applied weekly gave the higher yield which corresponded to irrigation at 0.2 to 0.3 atmosphere moisture tension. 120 lb. N/acre seemed to be the optimum dose of nitrogen. There was no inter-relationship between the levels of irrigation or nitrogen and their effects were mainly additive.

7. *Thomas, A. I., Studies on the manuring of tobacco* (*Nicotiana rustica L.*)

Effect of doses of nitrogen, phosphorus and potash applied as ammonium sulphate, single superphosphate and sulphate of potash @ 40, 80 lb. each per acre was studied on the yield of *hookah* tobacco (*Nicotiana rustica* L.) variety N. P. 18. The optimum requirement of nitrogen appeared to be in between 40 and 80 lb. N per acre, while for phosphorus it was 80 lb. P_2O_5per acre. Application of potash had no effect on crop yield. In general nitrogen application delayed maturity while phosphorus hastened it.

8. *Morey, M. D., Studies on the after effects of phosphate manured berseem on wheat*

To assess the after effect of berseem manured with phosphate on the yield of succeeding wheat crop and fertility status of the soil, the field experiment was conducted during rabi 1957. After effects of higher dose of P_2O_4 were more as regards grain and straw yields of wheat. Application of superphosphate alone or in combination with farmyard manure left greater residual effect compared to application of farmyard manure. Fallow-wheat rotation was found to be better compared to cowpeas-wheat rotation in producing wheat yields. It was further observed that fertility status of the soils in respect of total nitrogen, available P_2O_5 organic carbon and water holding capacity was highly built up in phosphate treated plots.

9. *Kanoje, S. L., Effect of varying doses of nitrogen and phosphate and different times of application of nitrogen on tomato*

Effect of doses of nitrogen (30, 60 and 90 lb. N/acre) was studied in combination with 20, 40 and 60 lb. P_2O_5 per acre when applied at 3 stages namely (i) full dose at transplanting, (ii) half dose at transplanting plus half dose 6 weeks after transplanting, and (iii) 1/3 at transplanting plus 1/3 6 weeks after transplanting plus 1/3 dose at blooming. Maximum yield of tomato was obtained with 90 lb. N plus 60 lb. of P_2O_5. It was further observed that application of 90 lb. N per acre brought about an increase in the number

of fruits per plant. However, the similar increase in the number of fruits was observed with 60 lb. N plus 20 lb. P_2O_5. Seed size was favourably influenced with a combined doze of 60 lb. N plus 60 lb. P_2O_5 Against this combination, application of 90 lb. N per acre gave lighter seeds.

10. *Shrivastava, M. M. P., Differential response of wheat varieties to fertilization with nitrogen, phosphate and potash and their combinations.*

During rabi 1957-58 the differential response of 2 wheat varieties *viz.* N. P. 710 and N. P. 718 to levels of nitrogen, phosphorus and potash was studied under irrigated conditions. It was observed that N. P. 718 gave better response to levels of nitrogen compared to N. P. 710. However, the response to doses of nitrogen was not significant. Application of 20 and 40 lb. P_2O^5 per acre increased grain yield of N. P. 710 by 3.14 and 4.43 mds. against the corresponding increase of 3.19 and 4.32 mds. in case of N. P. 718. Application of 20 and 40 lb. K_2O per acre showed no response and no differential behaviour for wheat varieties.

11. *Sahai, N. N., Study of the response of* boro *rice to various types and levels of nitrogen in combination with phosphate and potash*

To determine the response of *boro* rice to various types and levels of nitrogen in combination with phosphate and potash the experiment was conducted at the Central Rice Research Instt., Cuttack, during the year 1957-58. Three levels of nitrogen were O, 40 and 80 lb. N per acre. Three levels of phosphate were 0, 50 and 100 lb. P_2O_5 per acre and 3 types of nitrogenous fertilizers were ammonium sulphate, calcium ammonium nitrate and urea. Three extra combination treatments were 20, 40 and 60 lb. K O per acre applied over 40 lb. N plus 50 lb. P_2O_5. With the increasing doses of nitrogen the grain and straw yields increased correspondingly. Application of phosphate and potash gave increase in yield at lower doses but at higher doses they were not found to be beneficial. Ammonium sulphate and urea were at par while calcium ammonium nitrate was found to be inferior to both these nitrogenous fertilizers.

12. *Panchbhai, K. R., Study of response of some* indica *and* japonica *types of rice to the various N and P levels in the* boro *crop season*

To study the performance of 8 *indica* and 2 *japonica* types of rice at 3 levels of nitrogen (0, 40 and 80 lb. N per acre) and 2 levels of P_2O_5 (0 and 50 lb. per acre) the experiment was conducted at the Central Rice Research Instt., Cuttack, during *boro* crop, season of the year 1957-58. Varieties C. B. II and Tepa I by virtue of their profused tillering habit gave the highest yield. Mtu. 15 with greater height, moderate number of earheads and more number of grains per panicle also gave high yield. The two *japonicas, viz.,* Norin 17 and Zuiho were found to be poor yielders compared to the *indicas.* All the coarse grained varieties of *indica* group were found to be high yielding as compared to the fine grained ones.

Interaction of varieties and fertilizer application was found to be significant and varieties showed a differential behaviour to various nitrogen applications. The *japonicas,* Norin 17 and Zuiho showed maximum differential response to nitrogen and phosphorous while among *indica,* two varieties, *viz.* Tepa I and C. B. II gave the highest response to nitrogen. Mtu. 15, Tkm. 6, Ptb. 10 and Co. 22 gave moderate response to nitrogen and Pla. 1 and Mtu. 9 gave the least response. Among the indicas, Tkm. 6 showed significant response to P^2O_5.

13. *Sadanandan, N., Effect of split application of nitrogenous fertilizers on the yield and other agronomic characters of rice* (Oryza sativa *L.*)

To study the effect of single, two split and 3 split application of ammonium sulphate, calcium ammonium nitrate and the combination of both on the yield and other yield attributing characters of rice, an experiment was conducted at the Central Rice Research Institute, Cuttack, during the main season of the year 1957-58. It was observed that application of the nitrogenous fertilizers in split doses gave higher grain yield compared to single application. The highest grain yield was obtained by application of 40 lb. of nitrogen in the form of ammonium sulphate in 3 split doses *viz.* 1/4th at transplanting; half one month after transplanting and the balance 1 month before flowering. In all the cases the split application was done in the form of pellets. The time of split application coincided with the period of vegetative growth in the early stages and ear initiation in the later stage. Thus application of fertilizer before flowering was found to be beneficial in increasing grain yield. Amongst the sources of nitrogen tried ammonium sulphate was found to be the best source followed by the combination of ammonium sulphate, and calcium ammonium nitrate whereas calcium ammonium nitrate was least effective.

14. *Pattanaik, J., Control of weeds in cotton by chemical and cultural methods*

To study the effect of 3 weedicides (TCA, PCP and 2, 4-D) in different doses and at different times of application (pre and post) in combination with hoeing on the yield of cotton, an experiment was conducted during *kharif* 1957-58. The results indicated that pre-emergence application of TCA successfully controlled annual grass and pre-emergence application proved better compared to post-emergence of this weedicide, while PCP proved more effective as post-emergence spray. It was further observed that hoeing combined with application of TCA and PCP gave better results in controlling of weeds compared to chemical or cultural treatment. Application of 2, 4-D gave significant control of broad-leaved weeds, annual grasses and nut grass. However, it adversely affected the growth of cotton plants and lowered the yield. In general, there were not significant differences in yield due to various treatments.

15. *Krishnamurty K., Effect of varying depths of cultivation, with various doses of manures and their methods of application on the yield of cotton*

To investigate the bullock cultivation with victory (5″ to 6″) followed by country, and country ploughing (4-15″) alone with placement and broadcast applications of 40 lb. of nitrogen in the form of ammonium sulphate and groundnut cake when applied alone or in addition to 80 lb. P_2O_5 per acre in the form of superhosphate, on the yield of cotton the experiment was conducted during *kharif* 1957-58. Studies on the structure and other physical constants of the soil revealed that country ploughing provided the best tilth and increased other tillage treatments. Placement of fertilizer gave higher yield compared to broadcast and it was more economical. Application of phosphatic fertilizers induced early maturity of boll and gave better fineness in fibre and increased fibre length.

16. *Karemore, G. M., Weed control by chemicals and cultural methods*

With the object of studying the efficiency of 4 weedicides *viz.* sodium salt of 2, 4-D, butoxy ethyl ester of 2, 4-D, sodium salt of MCPA and sodium salt of MCPB applied at pre and post-emergence compared to cultural methods *viz.* hoeing and hand weeding, on

the yield of peas an experiment was conducted during *rabi* 1957-58. It was observed that pre-emergence application of the 4 weedicides controlled the yields only to an extent of about 50% whereas application of the same weedicides on post-emergence stage brought about almost complete control of broadleaved weeds. However, post-emergence application of all weedicides except MCPB had an adverse effect on the crop and killed about 32% of the plant population resulting in significant depression in the yield and net loss compared to control plots. Considering the cost of weedicides and their application it was found that application of sodium salt of MCPB applied at post-emergence stage @ 12 oz. a.e. per acre proved to be the most profitable and economical weedicide in controlling weeds in peas.

17. *Chatterjee, P. K., Response to sources and levels of nitrogen in combination with different doses of phosphate on wheat.*

To find out the difference in relative performances of three sources of N fertilizers, as also the optimum combination of N and P fertilizers on wheat an experiment was conducted during rabi 1957-58. The soil was rather very high in N and available K, but moderately deficient in available P_2O_5. The results indicated that increasing N doses in general did not have any influence on the growth characters like tiller number, growth in height, leaf number and dry weight per plant. P levels, on the other hand, showed significant effect on the above mentioned growth characters. Among the sources of nitrogen, ammonium sulphate showed better performance than ammonium nitrate or urea. There were no significant differences amongst the sources and the levels of N in increasing grain yield. Increasing doses of P, however, significantly increased the yield of total produce and grain. In the extra combinations with higher doses of N and P, N40P80 gave the highest yield of grain and maximum net profit per acre. Maximum loss due to lodging was observed in plots treated with N60P80. On the whole, phosphorus was the key factor on the performance of crop growth and ultimate yield.

18. *Shrivastva, R. S. P., Effect of application of different doses of nitrogen, phosphate, and molybdenum on cauliflower.*

An experiment on cauliflower to test the effect of different doses of N, P and Mo was conducted at I.A.R.I. in *rabi* 1957-58 for the third year. The doses of N, P and Mo in lb. per acre were, N :—0, 60 and 120; P :—0, 40 and 80; Mo :—0, 1 and 2. The result indicated that N120P40 was economical dose for cauliflower crop and it gave a profit of Rs. 419.00 per acre over the control, while application of N120P80 gave the highest yield of 224.38 mds./acre. Addition of molybdenum did not add to the yield of cauliflower crop.

19. *Mandal, B., Interrelationship of cultivation treatments, levels of nitrogen and irrigation interval on sugarcane*

To study the effects of three depths of preparatory tillage (C_0=4" with desi plough, C_1 6" and C_2 = 10 "with tractor plough) in combination with three doses of nitrogen (N_1=80 lb., N_2=120 lb., N_3= 160 lb. N/acre) and three intervals of irrigation (I_1=10 days, I_2=15 days and I_3=20 days) on the growth, yield and quality of sugarcane crop, the field experiment was conducted at I.A.R.I. The increased yields of sugarcane and sugar by deeper tillage were not significant over those of shallow tillage. The yields increased significantly upto 120 lb. N and 15 days interval of irrigation. The response curves, both of N and irrigation, showed quadratic relationship.

Soil studies revealed better aggregation with deeper tillage, but its effect on growth character was significant. Higher doses of nitrogen and shorter intervals of irrigation increased the number of millable stalks and cane height significantly upto the optimum dose of 120 lb. nitrogen and 15 days of irrigation interval. During active growth phase the percentage of leaf nitrogen on dry weight was 1.685 and 1.568 and the percentage of sheath moisture on green weight was 84.00 and 85.33 for 3rd (June) and 5th (August) months respectively under the optimum levels of nitrogen and irrigation. Shallower tillage, higher doses of nitrogen and shorter intervals of irrigation favoured surface rooting, whereas deeper tillage and deficient irrigation promoted deep rooting. The cane quality remained unaffected by any of the treatments.

20. *Awatramani, N. A., Effect of varying soil moisture regions and methods of irrigation in relation to nitrogen on tobacco crop* (Nicotiana rustica)

To study the effect of 5 levels of nitrogen, 2 methods of irrigation and 4 water regimes on tobacco yield the field experiment was conducted. 120 lb. N per acre was found to be the optimum dose. In addition to increase in yield, increase in the dose of nitrogen improved nitrogen and nicotine content. The study further revealed that maintaining moist regime *i.e.* irrigating tobacco when soil moisture tension was between 0·30—0·50 atmosphere was the best in yield, from amongst the four regimes tried. Both the wet regime (irrigation at 0.20–0.30 atmosphere) and dry (irrigation above 0.70 atmosphere tension) adversely affected the yield. Dry regime was the best from the point of view of quality as given by nitrogen and nicotine content.

Method of irrigation had no influence on the yield or quality of tobacco but it saved water to the extent of 9 per cent. Soil moisture studies indicated that for the production of same amount of dry matter saving of 40% water resulted through nitrogen application at 160 lb. per acre. 75—87% of the total water used by the plant came from upper 24 in. layer. The zone of maximum root activity was 3—6 in. and 6—9 in. later stage.

21. *Gautam, R. L., Role of extension education in the promotion of better village cooperatives*

Investigation was carried out with the objectives (i) to assess the effectiveness of 2 selected extension media in informing the people about (a) cooperation in general and cooperatives in particular, (b) their own rights and duties as members and (c) how to participate in the routine management and working of the societies so as to stimulate a healthy social consciousness; (ii) to make a comparative study of some of the different socio-economic factors which might promote cooperation among the farmers and (iii) to improve and develop cooperative outlook of the village people. The extension methods were exposed to 3 categories of persons *viz.*, the managing body members, ordinary members of the societies and the non-members in each village. The study revealed that the managing body was more responsive to the knowledge of cooperative principles and basic theories of cooperation under the personal contact method. In case of ordinary members personal contact accompanied by literature proved very effective; while in case of non-members discussion, meetings and audio-visual aids proved the most effective combination of extension methods.

Leadership in case of cooperative movement has been found to be one of the most important factors contributing towards the success or failure of the cooperative. Leaders with educational background and of middle age definitely made the programme successful.

22. *Belsare, A. R., Agricultural extension through rural leaderships*

Contrary to the general notions, physical and tangible factors such as age, literacy, size of family and holdings and income do not have any significant influence on the leadership status of persons who formally or informally are looked up as leaders in local community. In contrast to these factors intangible personal attributes of the leaders count heavily in local village opinion. This study further revealed that attributes such as earnestness and enthusiasm to serve, sociability and tactfullness when combined with middle sized family and economic status of the leader, have resulted in higher significant correlation with actual participation.

23. *Saxena, K. K., Efficiency of the village level worker as affected by different levels of academic standards and the influence of rural and urban*

In Extension-*cum*-Training Project, Bakshi-Ka-Talab, Lucknow, efficiency of Village Level Worker was studied in relation to his academic standard and rural or urban background during his early period. The study revealed that the village level worker having intermediate training and rural background gave the best performance. This combination favourably influenced his capacity to overcome difficulties experienced in field work, expression and presentation power, knowledge of rural conditions, sociability, perseverence and intensity of influence on rural people.

24. *Balwant Bhatt, Agricultural extension through rural youths*

To determine the effectiveness of extension methods as well as productivity of extension education in cultivating interest in rural youth for agricultural development programme the study was undertaken with 70 boys. It was observed that age and educational qualifications have a relative effect in achievement of knowledge and skill of boys while the size of holding of land showed a varying influence among the boys. Younger boys and those studying in higher classes brought about the maximum change in the practices of their parents. Increase in change of attitude of boys was associated with increase in their age, educational qualifications and size of land holding.

25. *Rao, C. S. S., Evaluation of extension methods for successful introduction of improved farming practices*

To popularize amongst the cultivations (i) introduction of *bajra* (*Pennisetum typhoidemn*) T. 55; (ii) pre-treatment of *jowar* (*Sorghum vulgare*) seed with Agroson G. N. and (iii) application of ammonium sulphate to *bajra* crop, the effectiveness of extension methods was studied. These methods were personal contact flannel-graph, method demonstration and their combinations. It was observed that of all the extension techniques employed the combination of personal contact, flannelgraph and method demonstration had the highest influence on the cultivations in adoption of the three improved farming practices. There was very high positive correlation between area owned, age of the cultivators vis-a-vis their knowledge, interest and attitude to adopt the improved farm practices.

26. *Sawhney, Man Mohan, Investigation into extension methods for introducing improved agricultural implements*

To determine the relative effectiveness of various extension methods for popularizing 3 agricultural implements namely Sharma hoe, Olpad thresher and furrow turning plough, an investigation was taken up with result demonstration, method demonstration, pamphlets

and their combinations. It was revealed that various extension methods differed widely in effectiveness and the effectiveness of a particular method was different on different cultivators depending upon their socio-economic characteristic. The study indicated that a large number of extension methods must be used to influence a larger population of cultivators.

27. *Sahoo, M. S., Effectiveness of certain extension techniques in relation to the socio-economic status of farmers*

A study was carried out to measure the effectivenes of (i) leaflet, (ii) personal contact, (iii) group discussion, (iv) method demonstration and (v) combination of the first three for execution of the programme of composting in relation to the socio-economic status of the farmer. There was no significant difference between the combination of methods and method demonstration and also between personal contact and group discussion. Leaflet was found to be the least effective. As regards the socio-economic status of the cultivators medium or large size of holding had the same effect while many of the cultivators had no influence on effectiveness of extension methods.

28. *Jakate, P. N., Relative effectiveness of extension techniques for success of soil & water conservation programme*

The effectiveness of five extension methods *viz.*, result demonstration, method demonstration, personal contact, group meetings and distribution of literature was investigated from the point of view of bringing about the changes in soil and water conservation practices followed in 5 villages covered by the Intensive Cultivation Scheme Area. The soil conservation practices adopted for this study were bunding, levelling, growing of legumes and application of fertilizers. It was observed that personal contact was most effective. It received 38.5 scores out of 100. Next to this was group meetings followed by result demonstration, method demonstration and distribution of literature. The last extension method proved to be the least effective. Amongst the practices recommended bunding, levelling and application of fertilizers have been found to be most popular and their combination proved very effective.

Division of Botany

29. *Dadlani, S. A., Embryological Investigations in some species and species crosses in the genus* Sesamum

Embryological studies have been carried out in some *Sesamum* species and species crosses to evaluate their compatibility relations and to observe embryo development.

S. prostratum has been found to be incompatible with *S. occidentale*; the flowers drop 2-3 days after pollination. Fertilisation has been found to occur quicker in the cross *S. occidentale S. prostratum* than in the female parent *S. occidentale* on selfing. Soon after the first division of the primary endosperm nucleus, however, further development becomes irregular and the endosperm degenerates. Chalazal haustoria fail to reach the nutritive pocket and subsequently the zygote also dies. Differences in the rate of embryo development have been found between a cross and its reciprocal and between hybrid and the parent.

30. *Thakare, R. G., X-ray irradiation studies in linseed*

It has been determined that a radiation dose of 10,000 r units does not reduce the germination capacity of seeds. Germination has been found to be somewhat improved in the case of the tetraploid seeds following irradiation. In general, plant height was reduced and flowering delayed in the treated material. That the radiation treatment induces structural changes in the chromosomes, such as reciprocal translocations, has been indicated by the presence of multivalent associations. The greater variability shown by the plants of X_2 generation appears to be of potential value to plant breeders.

31. *Sastry, G. R. K., Mutation studies on cotton and wheat*

The effects of ionising radiations have been studied on seven varieties of cotton belonging to two diploid species, *Gossypium arboreum* and *G. herbaceum* and two tetraploid species *G. hirsutum* and *G. barbadense*. The tetraploid cottons have been found to be more resistant to radiations than diploids with reference to survival and ability to tolerate chromosome aberrations. The variability induced by mutagens in this crop appears to be more of a continuous nature.

The second generation irradiated material of wheat variety N. P. 797 has been studied to isolate mutations. Several useful mutants like awned plants, erectiods and plants with increased tillering habit, yield, seed weight and better quality of the grains have been isolated. It has been concluded that the outlook for mutations in polyploid plants like bread wheat and Upland cotton is hopeful, contrary to earlier views that gene duplication in polyploids may suppress the expression of mutations and thereby render such plants unsuitable for mutation breeding.

32. *Alexander, M.P., Studies on induction and evaluation of polyloidy in some ornamental plants*

Observations on the induced tetraploids have shown that the most striking improvement in the floricultural value on chromosome doubling is achieved in *Antirrhimum*. The disadvantage of reduced seed setting is compensated to a great extent by increase in the number of flower per plant in the tetraploids of this plant.

A detailed cytological analysis of a number of tetraploid plants in each of the different winter annuals has shown that the variation in pollen fertility is generally correlated with the coefficient of realisation of multivalents in the pollen mother cells. Seed fertility in tetraploids has not been found to be directly related to pollen *fertility* and it has been concluded that genetic factors in addition to the irregular meiosis are responsible for reducing seed setting in the polyploids. Considerable variation in seed setting capacity of different tetraploid plants of the same species indicates that fertility in them can be improved by following a programme of hybridization and selection in subsequent generations.

33. *Bose, A.K., Studies on cytogenetical effects of radiation treatment in some ornamental plants*

Dry and water soaked seeds of a number of ornamental plants have been given X-ray treatments with a view to producing changes in the hereditary material which may be of practical interest.

Phenotypic changes in flower form which appear to be genetically determined have been observed in annual Chrysanthemum and Cosmos. The induced phenotypic effects in Chrysanthemum include a change in flower form from single to double of several different kinds and conversion of open petals into tubular types similar to those characteristics of the perennial varieties. Induced variation in Cosmos includes a marked increase in the size and number of flowers in several plants. The critical dose for the induction of mutation has been determined in several other garden plants.

A radiation induced change which results in partial asynapsis has been found to occur in some of the X_1 plants of Larkspur. An interesting finding made in this material is the existence of a competition for chiasmata formation between different bivalents in pollen mother cells.

34. *Makhija, O. P., Studies on the mode of inheritance of seedling reaction to different races of the three wheat rusts in some intervarietal crosses of* Triticum aestivum *L.*

The crosses involving the varieties, NP 710, NP 718, NP 775, NP 789, NP 790, Pb. C. 518, Pb. C. 591, Kenya E 220, Kenya E 518, Frondoso (E 771), Timstein derivative (E 871) and Rio Negro (E 952) belonging to *Triticum aestivum* L. have been studied for seedling reaction to three races (15,21,75) two biotypes (15 c and 42B) and one colour mutant (15c) of black rust (*Puccinia graminis tritici*).

Resistance to several races has been found to be monogenically dominant over susceptibility in ten of the crosses. Susceptibility to some of the other races has been found to be dominant over resistance in six of the crosses. Resistance to several of the races has been found to be controlled by two duplicate factors or a single gene. Varieties E 220 and NP 790 have been found to carry the same genes for resistance to race 15. Different genes which are not linked in their inheritance have been found to determine resistance to races 75 and 15c colour mutant.

35. *Ramarao, M., Study of genetic variability in some varieties of* Gossypium hirsutum *L. with regard to neppiness*

Nine varieties of cotton belonging to *Gossypium hirsutum* L. were sown in a compact family block layout with six progenies in each with the object of studying the genetic variability and heritability with regard to neppiness and other characters associated with it. Significant differences between the varieties have been shown to exist. Estimates of heritability showed that the genetic spectrum was masked to a lesser or greater extent by environmental factors in the case of neps and seedcoat fragments. The heritability has been found to be relatively greater in respect of motes. Correlation studies have shown that a positive but non-significant correlation existed between seedcoat fragments and chalazal-end damage and a negative and significant correlation between seedcoat fragments and lint index. The low heritability values have suggested that there is no room for further selection and that the environment plays a role in masking the genetic differences.

36. *Maherchandani, N., Studies on Solanum rybinii*

Two clones of *Solanum rybinii* and their selfed progeny have been studied from the point of view of their morphology, embryology, cytology, self and cross-incompatibility reaction to fungal and virus diseases, and food value. Embryosac formation has been found to follow the method typical of other *Solanum* spp. A few abnormalities like presence of double archesporium, two embryosacs in the same ovule and formation of embryosac from any of the megaspores of the tetrad have been observed.

The colchicine induced tetraploids have been found to show meiotic abnormalities such as asynapsis, unbalanced distribution at Metaphase II, formation of micronuclei, spindle errors etc. All the clones have been found to be susceptible to virus X, immune to virus Y and G and tolerant to virus A. In food value, the species is comparable to many other *tuberosum* varieties and can be safely used for breeding.

37. *Jain, K. K., A comparative study of the diploid and autotetraploid* toria *with special reference to the estimation of some genetic constants as aids to selection*

In an attempt to improve the efficiency of selection in colchicine induced autotetraploids of *Brassica campestris* var. *toria*, a cross fertilizing oilseed crop, genetic constants like correlations between yield and other characters; genetic coefficient of variation and estimates of heritability have been worked out. Selection indices have been constructed and the genetic gain that would accrue out of selection based on these indices forecast.

Heritability estimates in general were higher in the tetraploids than in the diploids. It has been concluded that from a breeder's point of view, pod index, seed weight and secondary branches are most important characters in tetraploids while primary branches, secondary branches and length of main shoot are most important characters in diploids.

38. *Nair, N. Rajappan, Genetics of rice* Oryza *L.): The inheritance of hairiness, clustering, beaked habit and anthocyanin pigmentation, and the interrelationship of genes governing these characters*

Twelve crosses involving twelve varieties of rice were studied to determine the number of genes governing such morphological characters as hairiness, clustering, beaked lemma-palea, glume length and anthocyanin pigment in different plant parts; their mode of action and inter-relationship. Mono, di, tri and tetra hybrid ratios observed earlier for the morphological characters and anthocyanin pigment in various parts have been confirmed by F_3 observations. Morphological characters excepting beaked lemma-palea have been found to be inherited independently of pigment. Genes for pigment in different parts are different but show linkage.

39. *Katwe, G. A., Breeding rice strains suitable for different levels of soil fertility, study of the F_4 generation of* japonica-indica *hybrids*

The F_4 hybrid cultures have been found on the whole, to be superior to the *indica* parents in total tillers, earbearing tillers, percentage of earbearing tillers, fertile and total spikelets, density of panicle, grain yield, straw/grain ratio and protein content. They combine early maturity with good plant height. The hybrid cultures were inferior in panicle length, spikelet sterility, 500-grain weight and straw yield. For cooking quality they were inferior to *indica* parents under normal fertility but gave variable performance at high level of fertility.

Promising selections with a mean single plant yield of 35.4 gms. in the normal fertility and with a mean single plant yield of 41.7 gms. in high level of fertility have been isolated; the mean single plant yield of the *indica* parents in the trial was 15.6 gms., and 20.9 gms. in the normal and high levels of fertility. The superior performance of the hybrids in most of the economic characters over the *indica* parents confirmed their adaptability for a particular set of environmental conditions and has indicated the possibilities of evolving useful strains for different levels of soil fertility.

40. *Nayar, N. Madhavan, Studies on the origin of cultivated rice,* O. sativa *L.*: *Cytogenetical studies of related species and their hybrids*

A study of the wild rices of Orissa has revealed the presence of a generally misidentified, perennial type, classifiable as *O. perennis* Meench. Cytogenetical studies have shown that this widely distributed species is closely related to cultivated rices, and that it possesses enough potential variability to produce plants having the recessive cultivated characters. The common wild rices occurring typically as weeds in paddy lands, termed as Spontaneas in this study, show characteristics of a hybrid origin. Morphological, ecological, cytological and genetical studies indicate that they are the result of introgression between *O. sativa* and *O. perennis* var. *balunga,* though it is possible that some Spontaneas have evolved directly from the latter species.

A study of the African wild and cultivated species has indicated a probable affinity between *O. perennis* and *O. glaberrima.*

Two allopolyploids from *O. glaberrima* × *O. sativa and O. sativa* × *O. breviligulata* have been synthesized. The nature of cytogenetic differences between the wild and cultivated species has been found to be due to allelic and also due to chromosomal differences such as cryptic structural changes and translocations.

41. *Patel, P. K., Economic evaluation of some of the American introductions of* Gossypium hirsutum *L.*

Thirty-three strains of American *hirsutums* were grown along with three Indian *hirsutums* at Delhi, during 1957-58, in a simple lattice design with three replications. They have been evaluated for 24 plant characters such as yield, maturity, and seed and fibre characters, in respect of intervarietal and intravatietial variation.

Majority of the introductions have been found to be characterised by poor yield, high susceptibility to jassid attack and heavy shedding of flowers and bolls. Only one strain S. A. 594 was observed to be jassid resistant, on par with the control H. 14 in yield and with significantly lower shedding percentage and higher boll bearing potential, but having low staple length, ginning value, and seed and lint indices. It may be useful in increasing the boll number of the standard variety. A majority of the exotics possess superior staple length upto 34·2 mms. as against 25·0 mms. of the standard. Some of the strains, *viz.,* S. A. Nos. 587, 463, 556 and 407 having staple length, 32·0 mms. and above, combined with fineness and maturity as good as that of the control, could be exploited usefully for further improving the staple length of the improved strains.

A few of the introductions, *viz.,* S. A. Nos. 105, 167, 533 and 574 possess ginning precentage above 36 which compares favourably with that of the control. Most of the introductions were big bolled and gave as high as 5.93 gms. weight of seed cotton per boll as compared to 3.33 gms. of the control, but they were found to contain higher percentage of motes.

42. *Chowdhury, A. P., Studies in induced tetraploids of berseem* (Trifolium alexandrinum *L.*) *and* senji (Melilotus indica *All.*)

In a parent progeny trial with 30 tetraploid and 3 diploid parental cultures, several tetraploid cultures out-yielded the 3 diploid parental cultures; several tetraploid cultures out-yielded the diploid strains in height, green fodder yield (2nd cut) and dry matter content (1st cut). While the green fodder yield of single tetraploid plants is considerably higher

than that of the diploid parents, the mean dry matter content of the tetraploids is slightly lower, and the existence of a wide range of variation in this character in tetraploids offers scope for selection and improvement. It has been found both in tetraploids and diploids that (i) fresh weight per plant is negatively correlated with dry weight percentage, (ii) dry weight is positively correlated with the number of tillers per plant, and (iii) plant height is negatively correlated with number of tillers per plant. The tetraploid berseem plants of C_4 generation have shown a relatively higher nitrogen and phosphorus content than the diploids. The tetraploids of *senji* have shown, as in the previous years, poor growth and vigour lower yield of green fodder, no regeneration capacity and greater susceptibility to aphid attack. Seed fertility in the C_4 terraploid berseem cultures showed further improvement. It has been concluded that on the whole, the outlook for improving the yield of berseem through the introduction of tetraploid varieties seems very hopeful.

43. *Jha, T. D., Genetic studies in barley—Inheritance of pigmentation and certain other characters in* vulgare *x* distichon *crosses*

The purple colour in leaf sheath, nodes, auricle, stem, awns and lemma in the parental variety E.B. 145 has been found to be dominant and determined by a single gene. The purple grain colour of this variety is also controlled by a single dominant factor which is allelic to the white grain colour of varieties K-215 and C-138-2 and grey colour of N. P. 13. The two-rowed condition of the spike and the hulled condition of the grains have both been found to be determined by single dominant genes. The development of anthocynine pigment in leafsheath, nodes, auricle and stem is due to the pleiotropic action of a single gene. Genes for several characters such as form of the ear and the grain, anthocyanin pigmentation in various plant parts, and length of the glume, have been found to be located on chromosome 1.

44. *Parmar, K. S., Study of the combining ability and the mode of inheritance of characters in some intervarietal crosses of* Triticum aestivum *L.*

With a view to determining whether early testing in wheat could be used as a basis for eliminating potentially poor yielding crosses, twelve intervarietal crosses of *T. aestivum* L. *i.e.*, the F_1, F_2, F_3 (20 families each) generations and the parents have been evaluated for grain yield, ear number, grain number, 100-grain weight, number of spikelets per ear, ear length, plant height and maturity period. In addition, the mode of inheritance of certain characters *viz.*, grain colour and lustrousness, awn colour and awning, colour and pubescence of glume, auricle hairiness, earliness and yellow spotting in leaves, has been studied in the same crosses.

The varieties have been found to differ widely in combining ability. Replicated yield trials of bulk crosses in F supplemented with F could be used to strain out potentially poor crosses. The parental varieties, E. 952, E. 957, E. 1913, E. 220, NP 790 and H. D. (52)-30 appear to be better for hybridization with NP 718 than others. Their residual vigour in F_2 of first three crosses, being 18·4%, 16·2%, 13·6% respectively, may be used for the exploitation of hybrid vigour in F_2, but its commercial application needs a thorough investigation.

45. *Ekbote, A. P., Economic evaluation of some of the Russian introductions of* Gossypium hirsutum *L.*

Thirty five Russian introductions of *Gossypium hirsutum* were laid out in a simple lattice layout with three replications and with H. 14 as control.

None of the introductions were found to be capable of direct economic exploitation because of their low yields. However, of the 15 cultures that were statistically at par in yield per plant, K 3482 (62.37 gms.) was found to be promising as against 61.24 gms. of H. 14. This culture besides being tolerably resistant to jassids was also characterised by high boll weight (4.17 gms.) as against 2.88 gms. of H. 14.

The Russian introductions did not appear to be outstanding as regards halo length. However, cultures K 3622 (31·0 mms.) and K 3792 (30·1 mms.) deserve mention, for these compare favourably with 25.9 mms. of H. 14.

46. *Pattanaik, G.B., Assessment of breeding value of certain Coimbatore canes*

In general, it has been found that in respect of confirment of the respective characters on the progeny, Co. 356 is inferior to Co. 453 for thickness of cane and brix, to Co. 617 for thickness of cane and lower weight of cane and superior to Co. 775 for thickness of cane and weight of cane. Co. 453 is as good as Co. 617, but superior to Co. 356 for thickness of cane and brix, better than Co. 775 for thickness of cane and weight of cane and brix. Co. 775 is a very poor parent because the progeny shows thin canes, low weight per cane, and inferior brix. It also gives progenies having excessive number of tillers—a *spontaneum* character. The progeny of Co. 313 is superior to that of Co. 617 in weight per cane brix and thickness. It is inferior to Co. 756 in that its progeny has comparatively lower brix than that of Co. 313, Co. 756 is superior to both Co. 313 and Co. 617 in respect of brix. Co. 617 has proved to be worse than Co. 313 and Co. 756 in combination with Co. 527. It has proved superior to Co. 356, Co. 775 and not significantly different from Co. 453 in combination with Co. 419.

Division of Entomology

47. *Kundu, G. G., Studies in resistance to some of the insecticides by beneficial insects (Parasites)*

The widespread use of the organic insecticides discovered during and after the second world war has created a number of problems. One of the most serious of these problems perhaps the most serious, is the development of resistance of insects to insecticides. Besides this resistance development their use has caused the destruction of beneficial parasites and predators that keep the pest population under effective check and maintain the balance of population in nature; and also the elimination of honey bees that are the natural agents of cross pollination and which bring about a significant increase in the yield of crops. This serious problem has attracted the attention of the economic entomologists all over the world. There is a large gap in our knowledge as to how this resistance is developed. The present investigation is an effort to fill some of this gap in our knowledge on this important problem.

Bracon brevicornis Wesm., a braconid wasp of great potentiality was studied for the development of resistance to p-p DDT and linadane under three different temperatures and humidities. Three postulates as the probable causes of the development of this resistance have been put forward *viz.*, dynamic variation, inheritance of resistance and mutation. The results obtained show that the development of resistance depends upon the environmental conditions. It was observed that there was difference in the development of resistance in

different temperatures and humidities although the insect species was subjected to the same insecticidal treatment. It may be safely concluded without fear of contradiction that the phenomenon of insect resistance could be the result of dynamic variation and environmental factors rather than inherited resistance through succesive generations.

48. *Anantha Krishnan, N. R., Effect of post-treatment temperature on insect susceptibility to insecticidal films*

Experminents were carried out to study the effect of seven post-treatment temperatures on the susceptibility of *Tribolium castaneum* Hbst. adults to emulsion films of five insecticides.

The L.D.50 obtained at the various temperatures for each insecticide is compared in the table given below :—

L. D. 50 *based on 3rd day observations*

Insecticide Emulsion*	DDT	Lindane	Toxaphene	Aldrin	Dieldrin
Number of insects used	1260	1260	1080	1260	1260
Post-treatment temperature (°C)					
10	0.06223	0.1545	..		
14—2	..	..	1.905		
15	..	..	..		
15—1	0.0706	0.1919	..		
20	..	..	..		
21—1	0.2489	0.2301	1. 6		
25	0.3524	..	1. 7		
26—1	..	0.2460	..		
30	1.033	0.3112	..		
30—0.5	..	..	0.7 1		
35	0.8790	0.2438	0.6918		
40	0.2037	0.1905	0.5768		

Preconditioning temperature 25°C.

*Exposure period for Toxaphene : 4 hours, for others 2 hours.

A study of L. D. 50 will show that with emulsion films of both DDT and BHC the mortality of the test insects decreased with rise of temperature from about 10 to 30°C and increased when the temperature increased from 30 to 40° C. on the other hand with emulsion films of toxaphene, aldrin and dieldrin the mortality of the test insects increased continuously with increase of temperature from 10 to 40° C.

Thus DDT and BHC show a negative temperature co-efficient from 10 to 30° C and positive temperature co-efficient from 30 to 40°C and in the case of toxaphene, aldrin and dieldrin there is a distinct positive temperature co-efficient from 10 to 40 C.

49. *Borle, M. N., Relative toxicity of different insecticidal films to the just-hatched larvae of pink bollworm* (Platyedra gossyplella *Saund.*) *of cotton*

The present investigation was undertaken to make the detailed study of the relative toxicity of some important insecticides with the view to find out the most effective insecticides for the control of pink bollworm.

The films were made on glass surface (in petridishes) with different concentrations of insecticidal emulsions and just-hatched larvae of pink bollworm were made to crawl on these films for specified periods of 20 minutes and 30 minutes in two separate series of experiments. Thereafter the larvae were removed to clean untreated petridishes and reared under as optimum condition as possible. Mortality counts were recorded at 24 hours interval up to 72 hours. As a result of these experiments, the following values of relative toxicity have been worked out.

In the first series of experiments with 20 minutes of exposure the relative toxicity of parathion, endrin, malathion, lindane, aldrin, dieldrin and toxaphene has been worked out to be 101·4, 47·32, 7·57, 4·478, 4·226, 3·263 and 0·8212 by taking LC 50 as a criterion and DDT as a base for reference.

Similarly in the second series of experiments with 30 minutes exposure, the relative toxicity of parathion, endrin, diazinon, malathion, lindane, aldrin, isodrin, dieldrin, toxaphene and chlordane has been worked out to be 71.52, 30.68, 7.925, 5.093, 3.055, 2.559, 2.398, 2.116, 0.2514 and 0.4466 by taking LC 50 as a criterion and DDT as a base for reference.

Observations on the development of the treated larvae that survived the treatment gave an indication that the larval periods get somewhat reduced except in case of DDT, pupal period slightly increased; sex-ratio gets disturbed in favour of larger number of males and fecundity of the females somewhat decreased.

50. *Afsarual Hakk, S., Systematic studies on the Indian Tingoidea*

The family Tingidae has been raised to the rank of super-family Tingoidea for the first time in India, comprising two families Tingidae and Piesmidae. One subfamily Phyllogasterotinginae, two genera Phyllogasterotingis and Bauhiniotingis and seven species 1. *Phyllogasterotingia achearanthi,* 2. *Bauhiniotingis naravana,* 3. *.Urentinus pusaensis,* 4. *U. indicus,* 5. *U. zizyphifolius,* 6. *U. sidae,* and 7. *U. euphorbiae* described herein are new to science. Genus Urentius Distant has been completely revised as it exists now in the world, with the addition of five new species to it, as stated above. A chart indicating the incidence of various tingid pests in Delhi has been prepared. Damage done by tingid pests to the plants of economic importance in India have been described in detail. The insect predator of tingid pests has been described separately. A full account of fifty genera and one hundred and six species described uptil now from the Indian region has been given.

A list of two hundred and fifty nine genera and two thousand and forty-two species, recorded so far under the superfamily Tingoidea in the world, along with full reference as to author, year and publication, has been prepared.

51. *Suchak, P. B., Comparative efficacy of insecticidal sprays against locust hoppers* (Locusta migratoria *Linnaeus* & Schistocerea gregaria *Forskal*)

The thesis reports the results of experiments carried out to determine relative toxicity of eleven insecticides against fourth stage hoppers of *Locusta migratoria* L.; that of two to second instar hoppers of *Schistocerea gregaria* F. and that of one to fourth stage hoppers of *S. gregaria*.. All these insecticides were used as emulsions prepared in the laboratory. The LC 50 value as calculated from log. concentration—probit mortality regression equations were found to be 0·003681% for endrin, 0·004797% for aldrin, 0·007762% chlordane, 0.01057% for dieldrin, 0.01153% for isodrin, 0.01648% for lindane, 0.02388% for malathion, 0.027004% for p-p' DDT, 0.02851% for systox, 0.03802% for diazinon and 0.05445% for toxaphene as tested against fourth stage hoppers of L. migratoria. Taking the toxicity of DDT as unity, the relative toxicity of these insecticides was : endrin—7·347, aldrin—5·637, chlordane—3·483, dieldrin—2·559, isodrin—2·345, lindane—1·641, malathion—1·132, systox—0.948, diazinon—0.711 and toxaphene—0.497.

The LC 50 values for aldrin and lindane when used against second instar hoppers of *S. gregaria* were 0.002118% and 0.002825% respectively, aldrin being 1.33 times as toxic as lindane to this hopper. The LC. 50 value of lindane against fourth stage hoppers of *S. gregaria* was found to be 0.01698%. Taking the resistance of second instar hoppers as unity, the fourth instar hoppers were found to be 6.01 times more resistant than the second instar hoppers.

52. *Rout, G., Relative efficacy of some fumigrants against* Tribolium castaneum *Herbst.*

Four fumigants *viz.,* carbon disulphide, ethylene dichloride and carbon tetrachloride and a mixture of ethylene dichloride and carbon tetrachloride (3:1 by volume) were tried against *Tribolium castaneum* adults in empty space. Carbon disulphide was found to be more toxic than any of the other fumigants which were almost equal in toxicity. When the fumigants were tried in presence of maize, barley and *jowar,* carbon disulphide was found to be most effective followed by carbon tetrachloride, EDCT mixture and ethylene dichloride. The results also indicated that *jowar* was highly sorptive material followed by barley and maize.

When carbon tetrachloride, EDCT mixture and ethylene dibromide were tried against *T. castaneum* adults buried at different depths in wheat, it was found that carbon tetrachloride was the most effective fumigant, followed by EDCT mixture and ethylene dibromide.

Effect of same concentration—time product, built up in different ways on the mortality of *T. castaneum* was studied. Carbon disulphide gave higher mortality of the insects with higher concentration combined with shorter exposure period, than with lower concentration combined with longer exposure period ; both combinations giving the same C-T product. But result obtained with ethylene dichloride, carbon tetrachloride and EDCT mixture showed that the different combinations of concentration and time forming the same C-T product sometimes produced mortality response which was significantly different. The results also indicated that carbon disulphide was more toxic to *T. castaneum* than carbon tetrachloride, ethylene dichloride or EDCT mixture; the last three fumigants were almost equal in toxicity.

53. *Khot, Nandini S., Taxonomy, bionomics and biology of entomophagous mites*

The widespread use of organic insecticides has created new problems. One of the most serious of these is the destruction of beneficial predators and parasites of mites, with the result that the mites that was not considered as a pest by economic entomologists has assumed the status of a major pest within recent years. Predatory mites play a vital role in keeping down the population of phytophagous mites. Very little research work has been carried out in India on the taxonomy and biology of entomophagous mites. So this aspect of the problem has been studied during the course of this investigation.

Out of five suborders of Acarina, suborders Mesostigmata, Trombidiformes and Sarcoptiformes have been studied. In the suborder Mesostigmata three families namely Phytosiidae, Aceosejidae and Macrochelidae have been studied. In the family Phytosiidae eight species have been studied as given below. Taxonomy of seven species of the genus *Amblyseius* has been studied; out of these species *Amblyseius cucummerius* (oud) is a new record. The remaining six species are probably new. The biology of one *Amblyseius* sp. (not yet named) was studied. The taxonomy of four species of the genus *Garmania* belonging to the family Aceosejidae has been studied. Out of these four species *Garmania domestica* (oud) is a new record, the rest of the species are probably new. The biology of Aceosejid mite (not yet named) has been studied. The taxonomy of *Macrochelus* sp. belonging to the family Macrochelidae has been studied. In the suborder Trombidiformes of the family Scutacaridae the taxonomy of Scutacarid mite and Erythraeid mite of the family Erythraeidae have been studied. These two mites are probably new genera. The taxonomy of three larval forms *Leptus* sp. and *Erythraeus* sp. of the family Erythraeidae and *Microtrombidium* sp. of the sub-family Microtrombidiinae has been studied. The taxonomy and biology of *Anystis* sp. of the family Anystidae has been studied in detail. In the suborder Sarcoptiformes of the family Acaridae the biology of *Tyrophagus putrescentiae* (Scha) has been studied.

54. *Gopinath K., Effect of temperature and humidity on the reproductive potential of* Apanteles angaleti Mues. (*Vipionidae* ; *hymen*)

Apanteles angaleti Mues, is an endoparasite of the cotton pink boll-worm in India. This potentially important parasite was discovered in 1954 and a large number of them have been imported by the United States Department of Agriculture for introduction and establishment in the cotton growing tracts of Mexico and some areas of the Southern States. Consideration of temperature and humidity in mass-breeding is of importance since they influence rate of oviposition and fecundity. During the course of the present investigations these factors were dealt with in some detail and the results obtained are as follows.

There was no appreciable pre-oviposition period and change in dietetic habits before oviposition. The parasite started ovipositing even when all food was denied to it from emergence, but the oviposition period was only one day and the number of eggs laid very low. The maximum number of eggs was laid at 25°C and increase and decrease in temperature makes it less fecund. The effect of temperature was most pronounced at 70% R. H. At 90% R. H. the effect of temperature was not marked, the difference in the number of eggs laid being negligible, increased rates of oviposition making up the number of eggs laid. The parasite prefers near saturation levels of humidity for egg laying and a comparatively dry atmosphere of 45% reduced the mean number of eggs laid to about one third. Raisin is far superior as food, sugar and Sorbitol solutions coming next in order. Light has a definite influence on the oviposition activities, maximum number of eggs being laid in presence of light.

55. *Sahu, J. P., Relative toxicity of insecticidal films to the just hatched larvae of sugarcane borers* (Chilotraea infuscatellus *Shell and* Scirpophaga nivella *Fabr.*)

This thesis reports the results of investigations carried out to determine the relative toxicity of insecticidal films to the just hatched larvae of *Chilotraea infuscatellus* and *Scirpophaga nivella.* The results obtained during the investigation are given below.

Films of nine insecticides were tested against the just hatched larvae of *Chilotraea infuscatellus* with an exposure period of 10 minutes and on the basis of mortality counts recorded 72 hours after exposure to the films, the LC. 50 values were calculated. These values of parathion, lindane, endrin, isodrin, pp-DDT, dieldrin, chlordane, aldrin and toxaphene were found to be 0.001627, 0.01932, 0.02659, 0.07866, 0.1939, 0.2869, 0.4169, 0.4595 & 0.5293 gm. per 100 c.c. emulsion spray. Parathion, lindane, endrin and isodrin were 119.115, 10.036, 7.288, 2.126 times respectively, more toxic than pp-DDT while dieldrin, chlordane, aldrin and toxaphene were less toxic to pp-DDT (0.675, 0.465, 0.422 and 0.366 times respectively as toxic as pp-DDT).

Films of two insecticides were tested against the just hatched larvae of *Scripophaga nivella* with an exposure period of 30 minutes and on the basis of mortality counts made 72 hours after exposure to the films the calculated values of LC. 50 of lindane and pp-DDT films were found to be 0.01185 and 0.09291 gm./100 c.c. emulsion spray.

Observations on the treated larvae which survived the treatment gave indications of larval and pupal periods getting somewhat reduced and the sex ratio being disturbed.

56. *Viswanathan, R., The Development of pink bollworm* Platyedra gossypiella *Saunders in different temperature and humidity conditions*

The development of pink bollworm, *Platyedra gossypiella* Saund. has been studied under combinations of seven constant temperatures ranging from 10 to 40°C and three relative humidities 30, 60 and 90%. Finally an attempt also has been made to explain the distribution of the pest in time and space in the light of the laboratory observations. The results of the investigations are as given below.

1. *Egg stage*

Temp. (°C)	30% RH.		60% RH.		90% RH.	
	Incubation period (days)	Viability %	Incubation period (days)	Viability %	Incubation period (days)	Viability %
10	Nil	Nil	Nil	Nil	Nil	Nil
15	21	4.7	19.7	32.96	20	31.3
20	10.5	77.8	10.14	89.6	10.16	91.8
25	6.3	76.4	6.3	96.8	6.24	97.8
30	4.3	80.0	4.1	96.4	4.1	98.5
35	3.75	5.8	3.6	81.9	3.6	84.4
40	Nil	Nil	Nil	Nil	Nil	Nil

The eggs kept at 10°C and 40°C did not hatch. But certain amount of development was observed in 10·C, which was evident from the change of colour of eggs from white to reddish brown.

2. *Larval stage*

The development of the larvae was studied only with respect to the effect of temperature on them. The effect of variable humidity was not studied because the larvae are internal feeder and always surrounded by cent per cent relative humidity. The observations on the larvae were as follows :

Temp. (°C)	Larval period	Viability %
10	Nil	Nil
15	Nil	Nil
20	26.32	17.73
25	17.52	27.9
30	12.22	20.78
33	11.59	20.0
35	Nil	Nil

At 10°C, all the larvae died. At 15°C the larvae lived for varying periods, maximum upto about 30 days, but none of them lived upto pupation. At 35° C all the larvae were found to die within two days of keeping.

3. *Pupal stage*

Temp. (°C)	30% RH.		60% RH.		90% RH.	
	Pupal period (days)	% of emergence	Pupal period (days)	% of emergence	Pupal period (days)	% of emergence
10	Nil	Nil	Not studied		Not studied	
15	51.5	22.2	51.4	87.5	51.9	80
20	21.75	61.5	21.27	91.3	21.0	86.7
25	12.87	88.2	12.10	94.4	12.4	100.0
30	9.6	69.2	8.7	100.0	8.7	100.0
35	7.5	54.5	7.23	92.9	7.5	84.6
40	Nil	Nil	Nil	Nil	Nil	Nil

At 10°C 60 and 90% RH have not been studied. In the same temperature at 30% RH no emergence was observed. At 40°C at all humidities, no emergence took place and the pupae were found desiccated after a week.

4. *Adult stage*

It was observed that females lived longer than males. Their longevity in number of days in different temperature and humidity combinations is given below :

Temp. (°C)	30% RH.		60% RH.		90% RH.	
	Male	Female	Male	Female	Male	Female
15	19.3	21.5	20	21.7	20.6	21.8
20	10.2	13.7	11	13.8	11.2	14.0
25	9.0	11.0	9.1	11.6	9.2	11.0
30	8.0	10.0	8.3	9.8	8.2	10.0
35	6.3	8.3	6.5	9.0	6.6	9.3
40	2.7	3.3	2.8	3.4	3.0	3.0
45	Nil	Nil	Nil	Nil	Nil	Nil

The study of the pre-oviposition period was carried out only in different temperatures and it was found to vary from 2–4 days in temperatures 20 °to 30 °C. At 35 °C no egg laying was observed.

In the course of the preliminary experiments some improvement also has been made and new observations recorded concerning the breeding technique of the pest.

Finally, after a study of the distribution of the pest in time and space in the light of the present observations it was tentatively held that the incidence of the pest in Bombay State has been unexpectedly very low due to some unknown causes, which need to be explored.

57. *Holkar, M. A., Toxonomic studies on Indian Fulgoroidea (Homoptera)*

This thesis embodies the work carried out by the author during the last ten months.

In the introductory chapter, what the fulgorids are, how they derived this name, the work done by different persons from various parts of the world on this group with special reference to the work done in India and the author's own contribution are dealt with.

In the second chapter, wherefrom the material has been procured and the methods of study are discussed.

Morphology being the most important basis for classification a chapter is devoted to the external anatomical features of these insects.

In recent years biology and bionomics of a group also have been found to have a definite bearing on taxonomy and so a chapter is devoted to this.

A historical resume of the classification of the Fulgoroidea follows with a key to the accepted families of this group.

The main part of the thesis comprises a taxonomic account of the various species of the Fulgoroidea recorded so far from the Indian Union to which the author has added five new species as follows.

I. Family Meenoplidae

(1) *Meenoplus indicus* sp. n.

(2) *Phaconeura delhiensis* sp. n.

II. Family Achilliidae

(3) *Deferenda narayani* sp. n.

(4) *Stiborus* sp., sp. n. (unnamed).

(5) *Satapa* sp., sp. n. (unnamed).

III. Family Flatidae

Division of Mycology and Plant Pathology

58. *Rajendran, V., Infection of wheat seedlings of different varieties with powdery mildew —factors affecting infection*

Studies on *Erysiphe graminis tritici* on wheat reveal that the conidia can germinate from 0° to 35°C, the optimum being 15°—20°C. Although germination occurred from 0% to 100% relative humidity, maximum germination was at 100% relative humidity at 15°—25°C. Germination at 0% relative humidity was present at 0°C. Light had no marked effect on germination. The germinability of conidia formed in January, 1958 was the maximum when the temperature ranged from 9° to 32°C. and it was completely lost towards the end of April, 1958 when the temperature ranged from 31°—47°C.

Host infection took place at 15° to 25°C and 20°C was the optimum. At 4° to 10°C infection appeared after 15 to 30 days. 25 to 75% relative humidity appeared to be ideal for infection although infection occurred from 0% to 100% relative humidity. Light of moderate intensity favoured infection. The minimum incubation period was 4 days when the temperature and relative humidity ranges were 13°—30°C and 45% to 89% respectively. Adult plants appeared to be resistant although slight infection appeared when the leaf surfaces were crapped off and inoculated. Ammonium sulphate, superphosphate, potassium sulphate and borax applied to soil had no effect on infection of seedlings grown in the fertilized soil.

Viability of the conidia was completely lost within 24 hours at temperatures above 25°C.

Cleistothecia appeared on young infected seedlings 2–3 weeks after inoculation but they were all immature. Potential asci were formed in some cases later on. Alternate freezing and thawing, and treatment with sucrose solutions and nitric acid solutions of different concentrations did not induce ascospore formation in the immature cleistothecia.

Of 26 varieties of wheat tested against *Erysiphe graminis tritici* Khapli was immune, Einkorn and Vernal were resistant while the rest were susceptible. *E. graminis tritici* also infected some grasses e.g., *Aegilops* spp., *Avena glauca* and *Lolium tenulantus.*

59. *Bhombe, B. B., Investigations in seed-borne diseases of vegetables*

A survey of seed micro-flora of 10 common vegetables collected from Delhi and other stations, was made. In all, 12 genera of the following fungi *viz., Alternaria, Aspergillus, Chaetomium, Colletotrichum, Curvularia, Fusarium, Gloeosporium, Helminthosporium, Peniocillium, Rhizoctonia, Rhizopus, Stemphylium* consisting of 45 isolates were obtained. Many of them were brought into pure culture and their cultural characters studied.

Artificial inoculations of the seeds with some important pathogens were carried out to determine their seed-borne nature and in those cases where the isolates were found to be positively pathogenic, their effect on seed germination and seedling growth and development was investigated.

The different methods commonly employed for isolation of seed-borne organisms and inoculation techniques to determine their pathogenic nature were studied and their relative merits assessed.

60. *Chandrasekhar, B. K., Studies on the movement of Sannhemp mosaic virus in Sannhemp* (Crotalaria juncea *L.*)

It was established that there is a considerable delay in the initial movement of the Sannhemp mosaic virus from the site of inoculation and the virus took about 3-4 days to move from the inoculated half of a leaf to the uninoculated half. The delay in the movement of the virus or the incubation period was found to be further influenced by the temperature at which plants were raised as also by the length of daylight period to which the plants were exposed. Lower temperatures and short daylight periods resulted in longer incubation period of the virus and delay in the appearance of symptoms.

On reaching the stem the virus was found to move usually in both upward and downward directions simultaneously but in a few cases it moved in the downward direction first and only in one case, it was found to have moved in the upward direction first. The virus was found to move to different parts of the plant, such as stems, roots and mature leaves below and above the inoculated leaf, although no visible symptoms were produced on them, suggesting that the virus is of a highly systemic nature. Pieces of uninfected tissues were, however, invariably detected in between the infected ones in certain plants.

In individual plants the virus was found to have travelled a length of about 25.1 cms. during the first 12 hours after entering the stem giving a minimal average rate of about 2.1 cms. per hour.

Defoliation of the leaves did not have any effect on the time taken by the virus to produce visible symptoms in the inoculated plants.

The Sannhemp plants could be successfully infected by inoculation of the roots with the infective sap by the pin prick method as well as by submerging the root regions of plants in the infective sap (1:10 dilution) for 24 hours.

61. *Quiniones, Sevastian S., Taxonomic studies on some species of* Collectotrichum

Thirty-one isolates of *Colletotrichum* have been studied on the hosts and in artificial culture media and seven specimens studied on hosts only. All the materials are referred to 9 species, namely ; *Colletotrichum capsici, C. falcatum, C. graminicolum, C. curvatum, C. gloeosporioides, C. lagenarium, C. lindemuthianum, C. pisi, and C. glycinicola sp. nov.* On the basis of the shape of conidia, the different isolates were grouped into two : (1) the straight-spored group and (2) the curved-spored group. Typical among the different isolates is the production of appressoria either from a short or long germ tube. These appressoria were variable in shape and as such could not be used in separating the species. The isolates behaved differently in both the synthetic and natural media. But if cultural characters are taken together, the isolates could be grouped into smaller components or even into species. The taxonomic treatment of the species has been based only on the conidial stage though two perfect stages were produced artificially on cut leaves and stems, which belonged to the *Glomerella* group.

62. *Dave, Bhalchandra C., Studies on bacteriophage for* xanthomonas citri (*Hasse*) *Dowson, the citrus canker organism*

The bacteriophage producing lysis of *Xanthomonas citri* (Hasse) Dowson, has been isolated from the diseased leaves of *Citrus paradisi* (grape fruit), as also from the soil samples collected from beneath the diseased citrus growing in the citrus orchard of the Horticulture Division, Indian Agricultural Research Institute, New Delhi. The properties of a single phage-isolate (isolated from the diseased leaves) have been investigated in the present study and it was found that the phage had a maximum "Titre" of 10^{9} , having 7×10^{9} phage particles per ml. of the stock phage. The selective liquid medium consisting of $MgSO_4$. $7H_2O$ (0.02%), KCI (0.02%), (NH_4) H_2PO_4 (0.1%) yeast extract (0.04%) and glucose (1.0%) and nutrient agar (having 1% agar) were found to be the best media for lysis and plague formation were 25°—27° and 27°—30°C., respectively, and the optimum pH at which the lytic principle was found to be most active was 7.5 for both lysis and plaque formation. The phage was inactivated by a 10-minute exposure at 75°C and by 9.5 ml. of chloroform per 5 ml. of the stock phage. The lytic principle was found to be host-specific and did not attack any of the other 19 species of the genus *Xanthomonas* tested. Similar host-specificities for the phages of some other species of *Xanthomonas,* namely, X. *pruni* (Thornberry, Eisenstark & Anderson, 1948, and Eisenstark & Bernstein, 1955) and *X. phaseoli* var. *fuscans* (Klement, 1957), have also been reported which indicate that there is possibility of using phage-reaction for delimiting species within the genus *Xanthomonas.* The fact that the phage for *X. citri* could readily be isolated from the soil samples taken from beneath the diseased citrus trees clearly indicates that its presence in the soil might have some adverse effect on the survival of the pathogen in soil. Secondary cultures of the test organism (*X. citri*) almost invariably appeared after some days in the liquid cultures lysed by the action of the lytic principle as also in the phage-treated agar medium seeded with the test organism and showing plaque formation.

63. *Laxminarayan, C., Further studies on sugarcane rust in India*

Studies on rust of sugarcane were continued during the year 1957-58. The techniques for inoculation and maintenance of this rust on potted plants as well as excised leaves were standardized. The effect of temperature on germination of uredospores and their viability was studied. The optimum temperature for uredospore germination was found to be 25°C. These were observed to remain viable for 17 weeks at 10°C. under conditions of very low humidity.

Twenty-five verieties of sugarcane were tested for their resistance to this rust. Of these, nineteen were found to be susceptible and the rest resistant.

Rusts naturally occurring on *Erianthus fulvus* and *Saccharum spontaneum* were also studied. The cross-inoculation tests with single-spore-cultures of the three rusts mentioned above, were conducted. It was thus observed that the rust on *Erianthus fulvus* (Simla) and *S. spontaneum* (Karnal) readily infected sugarcane (Co. S. 510). However, sugarcane rust (Nellikuppam ; Co. 697) did not infect *Erianthus fulvus* or *S. spontaneum*.

Detailed morphological studies of the uredo-and teleuto-spores of the three rusts were undertaken and it was concluded that the sugarcane rust was *Puccinia erianthi* Padwick and Khan.

64. *Agrawal, Hari Om., Studies on the factors affecting production of perfect stage of* Colletotrichum falcatum *Went*

The optimum temperature for the production of perithecia has been found to be about 25°C. No perithecial formation was found at 35°C. or above. Perithecia developed under artificial conditions only when the leaf-pieces were in direct contact with water. They could not be produced even at 100% relative humidity without direct contact of water. Perithecial formation was doubled by exposure to day-light at 10 hours/day as compared to that in its absence. Mature perithecia could be produced on dry and autoclaved leaves of *Erianthus munja, Sorghum valgare, Bambusa* sp., and on the green leaves of *Sorghum vulgare,* besides old and dry leaf blades of sugarcane. Few mature perithecia could be observed on unautoclaved (surface sterilized) green leaves of sugarcane. The intensity of perithecial formation varied amongst leaves of different varieties of sugarcane. Only two isolates produced perithecia out of 28 different isolates of *C. falcatum,* when inoculated artificially.. Even one of these two isolates lost the capacity to produce any perithecium at a later stage.

65. *Sen Gupta, P. K., Further studies on the biological activity of the active principle secreted by* Bacillus subtilis *Cohn. Emend. Prazmowski in soil and plant (Effect of molasses etc.)*

A study of the biological activity of the antibiotic substance secreted by *Bacillus subtilis* in soil and plant and its use as soil and seed inoculant for the control of pigeon pea-wilt was made. Mustard cake and molasses were found to be very good sources of nutrition for the production of the antibiotic substance by *B. subtilis* in soil. However, a combination of both molasses and mustard cake gave nearly two times more antibiotic production in soil than that could be obtained by either of the two. The high yield of antibiotic in molasses supplemented soil was shown to be due to the combined effect of some vitamins and amino acids coupled with some source of reducing sugar. When added to the soil the antibiotic principle was found to be adsorbed to it, the adsorption being more in clay

soil than in sandy loam. Considerable reduction in the incidence of pigeon pea wilt was obtained in pot experiments by seed bacterisation or soil inoculation with *B. subtilis*. The antibiotic principle was more stable in the leaves than in the roots or stems of pigeon pea plants.

Division of Soil Science and Agricultural Chemistry

66. *Karale, R. L., Effect of rainfall on the soils developed from the basalt rock, in Bombay Deccan*

In the present investigation, a distinct relationship was found to exist between soil properties *viz.*, the contents of clay, $CaCO_3$, MgO, CaO, P_2O_5 and rainfall. The content and nature of the clays as affected by rainfall are directly reflected in the related soil properties like water holding capacity, cation exchange capacity, volume of expansion and moisture equivalent.

In general, soils from low rainfall regions are black in colour, poor in organic matter, alkaline to neutral in reaction and better supplied with exchangeable bases. Silica content of these soils is fairly high and the contents exceeds that of alumina in the surface layers. Because of the montmorillonite nature of their clays, these soils show high cation exchange capacity and are fully saturated.

Soils from the high rainfall region are reddish to brown in colour, clayey in nature, acidic in reaction, and devoid of water soluble salts. These are rich in organic matter and give high values for water holding capacity, moisture equivalent and percent porespaces. Silica content is low in the surface soils but increases with the depth. Kaolinite is the predominent mineral of these soils together with traces of montmorillonite and illite. Despite the high clay content of these soils they show low cation exchange capacity because of the kaolinitic nature of their clays.

Soils occurring in the areas receiving 50″ 80″ rainfall can be grouped in between the above two types and their clay mineral is more illitic in nature. For this investigation, six profiles developed over basaltic parent rock, under different rainfall conditions, in Bombay Deccan were collected and studied.

67. *Gawande, S. P., Formation of black soil from basalt as related to slope*

Slope was observed to influence, to a great extent, the formation and development of profiles of black soils, collected on a continuous slope in Amraot (Bombay). Depth of the solum increased with decrease in the slope percentage and was maximum in the depression at the end of the slope (variation was from 4 inches to 27 inches) *pari passu* with the increase in the intensity of black colour and gradational change in the soil characteristics. The surface soils down the slope are characterised by change in structure from granular to cloddy, pH from acidic to alkaline, texture from clay loam to clay and increase in the contents of free sesquiosides and base exchange capacities.

These observations showed that the profiles were developed by the transport of fine soil materials downwards from higher slope and the deep profiles were formed by the accummulation of these soil materials under impeded drainage conditions. The uniform composition of the clay fractions and predominance of montmorillonite clay minerals supported this view. Topography was thus found to influence the formation of black soils under the uniform conditions of other soil forming factors, *viz.*, climate, vegetation, parent material and age.

68. *Umar, S. M., Time of soil sampling in relation to crop responses and nutrient availability*

The available nutrients, pH and soluable salts were found to fluctuate during the ifferent months of the Delhi soil in cropped, fallow, manured and unmanured conditions oth in the surface and sub-soils. The values were lowest in the months of December and ebruary and highest in the month of June irrespective of the treatments both in the surface nd subsoils.

Laboratory studies on the effect of changing temperature and moisture on nutrient vailability in five typical soils of India showed that both the factors contribute to bring bout the variations in the values, particularly with respect to potassium.

On the basis of correlation obtained between available nutrient values during differ-nt times of the year and wheat crop responses, it was found that the best time of soil sam-ling for nitrogen and phosphate was before sowing of the crop and for potassium imme-liately after the harvest of the crop.

69. *Kanzaria, M. V., The study of the effect of continuous manuring and cropping on soil fertility in Pusa permanent manurial experiments*

A study has been made on the effect of continuous manuring and cropping on soil fertility in the Pusa permanent manurial and rotational experiments, in progress since 1930-31. For this purpose soil samples from all the plots and samples of wheat crop, com-ing in rotation in one of the series, have been examined in the laboratory. It has been ob-served that :

1. Continuous cropping without any manuring has brought about marked deteriora-tion in soil fertility as judged from crop yields and nutrient status in the soil. Even green manuring or growing legumes in rotation has not maintained the fertility level of the land.

2. Farm-yard manure has given a consistently high yield of crops and has also con-tributed substantially towards improving the organic matter and nitrogen levels in the soil.

3. Green manuring with phosphate has given the highest yields of wheat and barley and also high yields of other crops, indicating its role to be as valuable as that of F.Y.M.

4. The value of N plus P artificial fertilisers in increasing crop yields has been prac-tically as good as that of F.Y.M. However, they have not been able to contribute much towards increasing the organic matter and nitrogen levels in the soil. Nitrogen alone has played a poor role. Effect of phosphate is quite pronounced. Potash has not proved to be of any value.

5. The C/N ratios of the soils have widened with the use of bulky organic manures and narrowed with ammonium sulphate application.

6. Phosphate manuring is associated with material increase in soil phosphorus, total and available.

7. No effect on the total Ca, $CaCO_3$, pH, water soluble salts and K_2O status of the soils has been observed under any of the treatments or rotations.

8. The relative fertility status of the soils has been reflected appreciably on the N and P composition of the wheat crop and more so on the total nutrient uptake by the crop

70. *Gopala Swamy, V., Studies on the fertility status of some peaty, marshy and swampy soils*

In the present investigation during 1958, attempts have been made to understand the fertility status of eight profiles consisting of twenty-seven soil samples collected from the Peaty areas of Kuttanad (Kerala), marshy areas of Sunderban (West Bengal) and from swamps of Bhubaneswar Agricultural Farm, Orissa; and to suggest a tentative classification of these soils and their reclamation practices.

The above soils having widely differing environment, were studied for their morphological, chemical and to some extent mineralogical characteristics.

All the soils investigated are on the acidic side with the pH ranging from 3.8 to 6. Those rich in clay and inorganic matter have greater reserves of acidity than the soils of lighter texture and lower content of organic matter. The C/N ratio of soils from Kuttanad is generally very high, whilst it is generally normal in the case of other soils. The soils from Kuttanad and Sunderban contain appreciable amount of salts which restricts the yield of many varieties of crops whilst salinity effects are negligible in the case of Bhubaneswar farm soils.

From the values of total nitrogen, P_2O_5 and K_2O and available P_2O_5 it is observed that the Kuttanad soils are medium, Sunderban soils are high and the Bhubaneswar soils are very low in their potential fertility status.

71. *Acharya, B.N., Fertility status of some acid soils in relation to availability of nutrients from some added nitrogenous fertilisers*

In the present thesis, study has been made of some physico-chemical properties of four profile samples having pH values 5.5 or less. Similar study has been made with ten surface samples (0-6″). A pot culture experiment has also been carried out with surface sample of acid soil (pH 5.5) from North Bengal with wheat in presence and absence of lime and organic matter and with addition of 30 lb. nitrogen per acre as ammonium sulphate.

It has been observed that the pH value of the soil profiles varies in different layers. The profiles as well as the surface samples are high in content of organic matter and nitrogen. In case of profile samples nitrogen and organic matter decrease with the depth of the profile. Total phosphorus (P_2O_5) is low in majority of the cases and is moderate in some cases and in a few cases moderately high. The total potash (K_2O) is low except in one profile (Shillong profile) where it is high. The total CaO is generally medium. The percentage of clay varies from 44.00 to 11.35 in the case of profile samples and from 20.75 to 45.25 in surface samples. The silica sesquioxide in HCL extract shows that the total quantities of soluble materials vary between 70-80 per cent in the profiles and in surface samples HCl soluble materials varies from 64 to 70%.

The results of the pot culture experiment show that the application of nitrogen increases the yield of straw and grain and placement has no beneficial effect over the surface application. Liming increases the yield and also the uptake of phosphorus. Next to lime the organic matter has got beneficial effect on uptake of phosphorus and yield of straw and grain. Liming also increased the pH of the soil from 5.5 to 6.1.

72. *Barooah, P. P., Studies on* Azotobacter *in acid soils*

This investigation deals with the distribution of *Beijerinckia indicum* (*Azotobacter indicum*) and *Azotobacter* spp. in fifty acid soils collected from different acid regions of India.

It was observed that *Azotobacter indicum* (*Beijerinckia indicum*) occurred in forty per cent of the soils. Some strains, contrary to earlier findings were isolated from soils outside the latitude 20 N other than laterite and lateritic formation.

The presence of *Beijerinckia* could not be correlated to any particular soil constituents in excess or to any particular type of vegetation.

The nitrogen fixing capacity of the strains of *Beijerinckia* varied from 5.97 to 11.57 mg. per gram of glucose during a period of one month.

Azotobacter spp. contrary to earlier observation was observed in nearly seventy per cent of soils examined. It was therefore evident that the genus *Azotobacter* is more widely spread than *Beijerinckia* even in acid soils.

In about twenty-six per cent of the soils examined, both *Azotobacter* spp. and *Beijerinckia* spp. occurred together. In about eighteen per cent of the soils neither genus was observed. No significant difference could be observed in the composition of these two groups of soils or in the nature of their native vegetation which could explain why organisms of both the genera were present in one group and absent in another.

73. *Chayanulu, M. V., The rhizosphere effects on microorganisms*

In view of the growing importance of the synthesis of growth promoting substances in the soil by bacteria and specially in the rhizosphere and in view of the observation made by different workers in the field regarding differences in the bacterial population in rhizosphere and arhizosphere, the present investigation was carried out to examine in the first instance whether there would be a difference in the microbial population in the rhizosphere and arhizosphere. The effect of nature of the crop and treatment on the bacterial numbers was also studied. This investigation was conducted with berseem and wheat crops in both pot and field experiments.

The conclusions obtained were mainly the following:—

(i) In berseem in both pot and field experiments there was a higher bacterial population in the rhizosphere than in arhizosphere. (ii) The same was the case with wheat so far as the pot experiments were considered. But the differences in the counts were not statistically significant in field experiment with this crop. This showed that in bringing about the differences the nature of the crop and the doses of fertilisers applied have an important part to play. The rhizosphere effect on the bacterial counts and crop yield was obtained in different treatments in pot and field experiments. This shows that the nutritional requirements of both organisms and crop were adequately met in the best treatments. (iv) A higher count of amino-acid requiring organisms was obtained in the rhizosphere of berseem in field experiment only, where the effect of direct application of fertilisers was in evidence, showing thereby that the berseem roots might have secreted the amino acids which could be utilised by the bacteria.

74. *DeDatta, S.K., Soil and fertiliser phosphorus used by legumes, effect of organic matter, silicates and chelates and study of their residual effects*

Use of soil and fertilizer phosphorus by berseem from a number of soils under the influence of different amendments like F.Y.M., sodium silicate and chelating agent (EDTA) has been studied. Different levels were tried : F.Y.M. @10 tons/acre, sodium silicate @ 500 & 3000 lbs/acre, EDTA@ 100 & 200 lbs/acre. Soils were distinctly different in their characteristics: red soil from Rudroor (Hyderabad), black soil (from Aliabada-Sourastra) and alluvial soils from Top Block (IARI), & diamond harbour (W. Bengal). Berseem was used as a test crop to ascertain the extent to which soil, and fertiliser phosphorus is taken up which was made possible with tagged superphosphate (P) Observations on yield of dry matter, total uptake, fertiliser phosphorus uptake and utilisation, uptake of soil phosphorus and Ca uptake, and available phosphorus, pH and fixing capacity were taken. It is observed that O.M. increased the yield, total uptake and in certain cases fertiliser phosphorus uptake.

Sodium silicate especially in the higher dose increased the yield of dry matter, total uptake, fertiliser phosphorus as well as soil phosphorus uptake and available phosphorus. In Top Block and Aliabada it has enhanced the fixing capacity. Yield was lowered with the addition of chelate. In the total uptake also with certain exceptions chelate had some detrimental effects. Lower dose decreased the uptake of fertiliser phosphorus. This detrimental effect was also maintained in the uptake of soil phosphorus especially in the higher dose. The availability of harvested soil was not altered by chelate though it has increased the phosphorus fixing capacity. Among the amendments used organic matter proved to be most promising.

75. *Deshmukh, P. L., Pedochemical characteristics of some alluvial soils in the Ganga-Yamuna Doab*

Five soil profiles, two in the district Etawah, one in the district Mainpuri, and two in the district Etah, in the Doab, under slightly varying topography and uniform climate were studied for their morphological, chemical and mineralogical characters.

On the basis of the field and laboratory data genetical designations of horizons have been attempted by defining 'A' horizon as the surface horizon having the highest organic matter mixed with mineral matter, 'B' horizon to the accummulation of clay, sesquioxides, magnesium etc., and 'C', horizon to the accumulated calcium carbonate layer.

From the data obtained on the chemical and mineralogical properties of the soils in the Doab, it may therefore be concluded that, profiles I, II, III and IV are almost similar, while profile V shows a different trend in the morphological and chemical characteristics.

76. *Deshpande, S. B., Foliar application of urea and sodium phosphate on barley*

A pot-culture experiment was conducted during 1957-58 with the object of studying the effect of spray application of urea and sodium phosphate on the yield and quality of barley. Also a comparative study of soil and spray application was made to investigate the comparative efficiency as indicated by the total uptake of nutrients such as N, P and K and the effect on the yield and chemical composition of grain and straw.

Spray applications of nitrogen increased the total dry matter, grain and straw yields, 1000 kernel weight, and was found to be somewhat superior to the soil application. Phosphorus application either to the foliage or to the soil generally had no effect.

The spray application of nitrogen increased the protein (both crude and true proteins) content of the grains. Percentage protein content was more in the case of soil application as compared to spray application but on the basis of per acre yield of protein, spray application is more effective. Ash, calcium and nicotinic acid contents also increased by spraying nitrogen.

The uptake of nitrogen, phosphorus and potassium showed an increase by both soil and spray applications of nitrogen. However, the spray applications were more effective.

Spraying of nitrogen at lower levels was as effective as the soil application at higher concentration level. This indicates the economic aspect of foliar application.

77. *Eshwarappa, H., Studies on organic phosphorus of black and red soils*

In the present thesis, study has been made of physicochemical properties of two neighbouring black and red soils from Mysore. A pot culture experiment with the surface soils from Raichur for determination of efficiencies of different sources of phosphorus for barley crop, reveals that the application of phosphorus increases the yield of straw and grain of barley. With both the soils triple super-phosphate is more effective as a source of P_2O_5 as compared to farmyard manure. So far as the relative behaviour of three organic phosphates on growth and yield of barley crop on black soil is concerned, nucleic acid shows the highest performance, followed by calcium glycerophosphate, followed by phytin. In the case of red soil of Raichur in respect of the average yield of straw and grain, nucleic acid shows the best performance, followed by phytin followed by calcium glycerophosphate. Triple superphosphate and farmyard manure show the same effect in respect of yield but in respect of uptake of phosphorus in crop, triple superphosphate has better effect than farmyard manure. Phytin shows better effect on red soil than on black soil.

The results of the experiments conducted emphasize the importance of soil in determining the ability of the plants to utilise added organic phosphates and triple superphosphate.

78. *Gurcharan Singh, Soil genesis from alluvial parent materials and the relationship of soil types to land use*

Six profiles *viz.,* normal cultivated, normal virgin, moderate alkali, alkali, water logged, (alkali) and alkalisaline were taken for the study. The soils were analysed for their machanical composition, pH, water soluble salts, physical constants, organic carbon, total nitrogen lime contents, estimation of HCl extract, available P_2O_5 and K_2O, total exchange capacity and exchangeable cations. Analyses of clays for normal cultivated soil profile and normal virgin soil profile were made.

Data show that the clay content, generally increases with depth in all the profiles except in the case of water-logged profiles. The soluble salts are low under good drainage conditions, the normal soils contain little $CaCO_3$ in the top and its pH is about 7.5. Lime occurs however, in other soils and in the form of Kankar also. The alkali and saline soils show high pH. The physical constants are in agreement with machanical composition data.

Clay mineral is predominantly of montmorillin group. Relationship of soil types to land use has been sought by taking into consideration crop yields and response to manures and fertilisers. Though their response is significant to some extent, more intensified work is needed to obtain a precise knowledge of the soil type and its use potential.

79. *Kalbande, A. R., Evaluation of soil test correlations at different doses of nitrogen applied to wheat in Delhi State soils*

The present investigation was aimed at assessing the comparative suitability of different methods of estimating available nitrogen in the soils of Delhi State as judged by the correlations between the soil test values with crop responses in pot, field and cup experiments.

The soil tests can be depended upon only when they are calibrated against actual yields in the pot experiments and then only it would be possible to predict the fertiliser needs for a particular soil test value.

The results obtained from such correlation study are briefly as follows :

The determination of total nitrogen or organic carbon is no index of the availability of nitrogen to crop growth in Delhi soils.

The incubation procedures have shown correlations between the mineralizable nitrogen values and percent yields on one hand and the uptake of nitrogen by the crop on the other hand.

Highest correlations with percent yield both in pot and field experiments were obtained in most cases with alkaline potassium permanganate method.

No correlation was obtained between surface soil and corresponding subsoil nitrogen soil test values.

The technique of growing crop for short time in limited amount of soil, shows that the nitrogen taken up by maize in a week is correlated at 5% level with the corresponding available nitrogen values as obtained with alkaline potassium permanganate method and mineralizable nitrogen obtained after 45 days incubation.

From the regression equations fitted with the data obtained between available nitrogen as obtained by alkaline potassium permanganate method with corresponding percent yields to each rate of nitrogen application, it will be possible to calculate the percent yields that can be expected at any soil test values from different rates of nitrogen application. In order to have more reliability, it will be necessary to evaluate such curves with the yield figures obtained over several years.

80. *Pillai, T.V.B., Physico chemical factors affecting the utilisation of some acid soils of India including* gari *soils*

The lime requirements of the soils studied were related to their organic carbon contents by the equation,

$$\%CaO = \frac{0{\cdot}86}{3{\cdot}09} \% \text{ Org. C}$$

It has also been found that liming generally reduced the group I clay-humus complexes and this new factor has to be taken into account in balancing the beneficial effects of liming with the harmful effects. Incubation and the addition of F.Y.M. to the soil were found to reduce their lime requirements.

There was generally no increase in the aggregation of the soil clays due to liming alone. The physico-chemical characterisation of the soils studied has shown them to be kaolinitic; Jenny's complementary ion principle was holding good in explaining the effects of liming on the availability of soil potassium.

As regards the effect of liming in lessening the fixation of phosphate the soils behaved largely as kaolinitic.

By the addition of bentonite with F.Y.M. and lime to the soil, the physico-chemical condition is so altered that the aggregation of silt has significantly increased in Agarthala Kuttanad and also to some extent in Chalakkudi and Raneswar soils. There was a beneficial effect as regards P-sorption in Kuttanad and Aryadu with, however, a depression in the diffusible K from the soil complex.

Practical advantage can be taken of this finding in raising the fertility of these soils after determining the minimum quantity of bentonite or black soil needed for this purpose.

81. *Raj Gopal, C. K., Studies on phosphate fixation and availability in some red and laterite soils*

Studies on phosphate fixation and availability of some typical laterite and red soils of the south showed that apart from the specific problem of free sesquioxides in these acid soils, the unavailability of phosphorus is due in substantial measure to adsorption and anion exchange reactions with clay and the unfavourable soil reaction.

The investigation provides the following experimental evidence on the scope of a consolidated approach in which each of these factors operating in the fixation phenomena may be significantly modified and the soil rendered amenable to phosphate fertilisation:

(a) Inactivation of sesquioxides by chelating chemicals like EDTA or organic compounds of this type present in organic manure which complex the sesquioxides.

(b) Blocking the mechanisms of fixation by clay by the use of organic ions in manures of the type of F.Y.M. whereby their isomorphous replacement in the crystal lattice reduces fixation of phosphorus.

(c) Amendment of the soil reaction and simultaneous restoration of base unsaturation, specially with calcium in the form of lime whereby fixation by anion exchange is reduced and availability of phosphorus compounds is increased by formation of assimilable calcium and aluminium phosphates.

(d) Utilising the specific property of sodium chloride to modify the physiology of cereal crops like barley so that they can assimilate fixed and difficulty available forms of phosphorus from such soils.

(e) The use of water insoluble fertilisers like bone meal and rock phosphate provides another useful alternative, to meet this problem. The dicalcium phosphate is, however, not effective.

The leguminous species of crops also benefit from the use of water insoluble fertilisers like bone meal and rock phosphate on such soils. Dicalcium phosphate again is not an effective fertiliser, in this respect, for acidic soils.

82. *Prasad, S., Pedogenesis of diverse types of soils occurring in close proximity*

Four diverse types of soils, differing widely in their characteristics, are observed in catenary sequence in the Raipur district of Madhya Pradesh and are locally known as Bhata, Matasi, Dorsa and Kanhar. Variation in colour of the surface soils is in harmony with the toposequence in which these soils are found to occur. Bhata is a redloamy soil usually occupying the higher level of a long slope whereas Kanhar is a black soil mostly confined to the depression at the end of the slope. Matasi and Dorsa, which are respectively yellow and brownish, occupy the intermediate positions in the descending order.

Drainage, the principal effect of topography, appears to be intimately connected with the formation of these soils and development of their profiles. Kanhar is thus formed under conditions of impeded drainage whereas Bhata under the condition of free drainage. The morphology, physical and chemical characteristics of the soils under investigation support the view and these proporties follow the same gradation as that of toposequence. As the depth of the profile changes from shallow to deep, texture and structure gradually improve down the slope, pH increases from acidity to alkalinity from Bhata to Kanhar passing through Matasi and Dorsa. Similar gradation is also found regarding the chemical composition of the soils. pH, zone of accumulation of calcium carbonate, reflect the condition of drainage. Effect of slope on the development of these souls is reflected in the uniformity of chemical composition of the clays of all the soils.

Further support regarding drainage condition is found in the cation exchange capacities of the soils which gradually increase from Bhata to Kanhar so also the case with free oxides of iron in these soils.

Predominance of montmorillonitic clay mineral in the clays decreases and that of illite increases up the slope, showing thereby the effect of drainage on the transformation of montmorillonite into illite. Montmorillonite is the predominant clay mineral in Kanhar clays and is gradually transformed into illite with increase in slope percentage—illite is the predominating clay mineral in Bhata.

Considering the sequence of the morphological, chemical and physical properties of these soils in conformity with the toposequence, and their occurrence in close proximity, it is proposed to term this group of soils as "Raipur Catena".

83. *Sinha, B. K., Studies on the nature of saline-alkali soils in South West of Uttar Pradesh*

Soils that have developed salinity alkali and only alkali under similar conditions of climate and topography in south west Uttar Pradesh are investigated for morpohological, physical and chemical characters.

Salinity alkali in profiles I and II (Dist. Etawah) is due to the low lying topography, poor drainage and salt accumulation under extreme heat and evaporation; in profile III (Dist. Mainpuri) and IV (Dist. Etah) due to the high water table and in profile V (Dist. Etah) due to degradation. The morphology, chemical composition of soil water extract and the nature of exchange complex vary from profile to profile. While the formation of $CaCo_3$ in these soils is due to the impedence of rising ground water and subsequent evaporation and precipitation, that of iron concretions is due to the alternating reduction and oxidation conditions.

Soils in profile I are just saline and the salt accumulation is due to the action of standing water saturated with salts for considerably long periods. In profile II, salts are very high at the surface and there is no leaching. In profile III carbonates are present only at the surface. In profile IV since the subsoil water is both saline and alkaline, salts are deposited by capillary action. In profile V,Na_2CO_3 is entirely absent.

On the basis of morphology and genesis the above soils have been classified as under:—

Profile I.—(Etawah)-Saline-Alkali, 'Solonetz' or 'Black Alkali' of Hilgard.

Profile II.—(Phaphund)-Saline-Alkali or 'Black Alkali' of Hilgard.

Profile III.—(Shikohabad)-Saline-Alkali or 'Sodium Solonchak'.

Profile IV.—(Etah)-Saline-Alkali-'Puff-Solonchak'.

Profile V.—(Kasganj)-Nonsaline-Alkali or 'Degraded Alkali' of Sigmond.

84. *Saolapurkar, V. K., Correlation of soil tests with response of wheat in Delhi soils.*

In order to evaluate a suitable soil test procedure for phosphorus, under Delhi soil conditions, a comparative study of different methods for extraction of available phosphorus was made. Green house and field experiments were conducted to find out the response to phosphate application on these soils. The evaluation of the tests was based on the correlation between laboratory results and greenhouse and field results. Percent yield and phosphorus uptake value and Mitscherlich's 'b' values were used for correlating the soil tests. The results obtained are briefly summarised as follows :—

(i) The general physical and chemical properties of the soils indicated that the soils are of inherently low fertility status.

(ii) The comparison of different methods for available phosphorus showed that as the acidity of the extractant increased the amount of phosphorus extracted from the soils studied, increased.

(iii) The greenhouse and field experiments indicated that the soils taken for the study were deficient in their available phosphorus content as judged from the response of wheat to phosphate application under greenhouse as well as field conditions. The degree of response under greenhouse conditions was of much higher order than under field conditions.

(iv) The correlations of the soil test values with the response of wheat were much better under greenhouse conditions than under field conditions. On the basis of correlation analysis for different methods, it was found that the correlations obtained from Alsen's 0.5M $NaHCO_3$ method were highly significant than other methods studied. The acidic extractants showed lower correlation coefficients in the greenhouse and field studies also.

(v) The lower degree of correlation under field conditions was found to be due to sub-soil phosphorus. The sub-soil phosphorus correlated better than the surface soil phosphorus with the response of wheat in fields. There was a close relation between surface soil phosphorus and sub-soil phosphorus.

Based on the correlation analysis and comparison of prediction values on linear scale, Olsen's 0.5M $NaHCO_3$ method was found to be best suited under Delhi conditions, and can be used to characterise the phosphorus fertility status under Delhi soil conditions.

85. *Subba Rao, D., Micronutrient status of the typical tobacco growing soils of Guntur-Godavari belt*

A study of the growth of the tobacco plant (H.S.) in pots using the typical soil samples collected from the Guntur-Godavari belt indicated to be the higher yielding soils in the fields proved otherwise in the pot culture experiments. The yield data seem to be in line with the higher values of clay. The copper content is also in a line with the yield data. Boron did not show definite trends as its uptake might largely be dependent on calcium. There is fair indication that very high values of manganese are not conducive for good growth. Shoot root ratio was found to be about 5:0 in all these samples while the leaf stem ratio varied considerably.

The values of the nicotine in the leaf samples seems to be low. This may be due to the fact that these samples were dried at 70°C for about 48 hours. The relative contents of nicotine indicates that the samples grown on Uppalapadu soils contain a higher value as compared to the results obtained from the leaf material grown on these soils. One factor that is prominent in these samples is its high copper content.

The trend of the results obtained in this investigation indicate the importance of manganese in the growth of tobacco. Boron seems to depend on the calcium contents of the soil and better indications can only be obtained if this element is systematically tried on the fields, keeping in view the calcium content of the soils. The present investigation throws light on the interrelationship and the importance of the major and micro-elements on the plant growth.

86. *Venkatachalam, S., Studies on some soil factors in evaluating the quality of irrigation water as regards their alkali hazards.*

The quality of irrigation water could not be judged from the analysis of the irrigation water itself but that some soil factors like cation exchange capacity and calcium carbonate besides its permeability must be taken into account.

At equilibrium, the rate of change of degree of sodium saturation (DSS) of the soil with sodium adsorption ratio (SAR) of the irrigation water decreased at higher values of the latter in the case of Pusa soil and increased with it in the red, black and Suratgarh soils in this order.

The deviations from the relationship found between SAR and DSS were less than those from the formulations of either Gapon or U. S. Salinity Laboratory.

The studies on the dispersion of soils treated with different irrigation waters showed that although at the point of dispersion the different soils had different values either for DSS or degree of dispersion (DD) or pH, the SAR value of the equilibrium solution that can be calculated from the relationship found in this investigation was nearly the same for all the soils being 11.45-0.5 and may serve as a better and more uniform index to characterise alkali soils than those proposed in literature.

Due to evaporation and the leaching action of rain water the effective SAR of irrigation water varied from 0.6 to 2.6 times the actual value in the irrigation water and was qualitatively related to the total surface area of the soils.

The same factors that were responsible for supply of irrigation water under conditions of no evaporation and no rain appeared to be also responsible for their deterioration due to evaporation.

87. *Vyas, K. K., Phosphorus fixation, availability and uptake by wheat and paday under different moisture and organic matter levels and the study of their residual effects.*

A green house experiment was conducted on several soils with wheat as a test crop to study the fixation, availability and uptake of soil fertiliser phosphorus at different levels of moisture and organic matter. Radio-active superphosphate at an activity of 0.15 me/g. P_2O_5 was used to supply a basal doze of 80 lbs. P_2O_5/acre. Three levels of organic matter (0, 10, 20 tons/acre) and 4 levels of moisture (100, 150, 125, 175%) were combined in a randomized design with 3 replications.

Observations on yield of dry matter, uptake of total, soil and fertiliser phosphorus have been recorded at three stages—30 days after germination, 53 days after germination and 71 days after germination. This last date which corresponded to flowering stage was when the crop was finally harvested.

The results obtained indicate that the yield of dry matter, uptake of total and soil phoshporus (including the contribution from organic matter) increased with increase in organic matter and moisture levels. The percentage uptake and utilisation of fertiliser phosphorus decreased with organic matter in all soils except in Koilpatti where an increase in uptake and utilisation of fertiliser phosphorus was noticed with increase in organic matter. The highest uptake of fertiliser phosphorus was found at moisture levels 100 to 125% in all soils. Organic matter increased the available phosphorus content in all soils while higher moisture levels were found to decrease it. The % phosphorus fixation capacity decreased with increase in O.M. and moisture levels.

88. *Nanda, S. S. K., Pedochemical characteristics of some red and laterite soils.*

An attempt was made to understand the genesis of a red and a laterite soil by studying their morphological features and chemical properties. Two aspects of the study were made: their field characteristics and laboratory analysis. A red soil in Delhi and a laterite in Orissa were chosen.

From data it is determined that red soil is derived from quartzite rock of Delhi by accumulation of liberated iron in a diffused state. In case of laterite it is a relative accumulation of sesquioxides through removal of silica and other soluble constituents. Physico-chemical studies like estimation of free sesquioxide content, fixation of phosphate from solutions and buffer capacity reveal that red colour is not only due to quantitative expression of iron, but it is also due to certain form and nature of iron present.

It is not adequate to classify them by giving certain limits in their physico-chemical properties.

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